UNIVERSITY OF CALIFORNIA,
IRVINE

Essays on Urban Economics

DISSERTATION

submitted in partial satisfaction of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Economics

by

Kyle Kole

Dissertation Committee:
Distinguished Professor Jan Brueckner, Chair
Professor Matthew Freedman
Assistant Professor Jack Liebersohn

2022

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

I would like to first thank my advisor, Jan Brueckner, for his expertise, guidance, and patience. Without a doubt, his wonderful mentoring has empowered me to achieve a level of research that I initially did not think I was capable of. The pandemic unfortunately cut our time in person short. Nevertheless, there will be future opportunities to meet again.

Next, I thank my committee members, Matt Freedman and Jack Liebersohn. Matt, I thank you for your big picture view, especially when it came to deciding which research questions to pursue. Jack, I thank you for your structured approach to framing research questions and presenting my results, it has substantially improved my ability to formulate and discuss research ideas.

To all my friends, family, and loved ones, thank you for your never-ending faith in my ability to complete this dissertation. Eda, thank you for your enduring support and encouragement. Mark, Arpita, and Maryam, I will never forget all our fun adventures in Irvine. My gratitude to the Thai Culture Association and Hmong Student Association at UCI for providing a community and many opportunities to pursue meaningful extracurricular activities.

Thank you to all those who have guided me in one way or another along the way: Mike McBride, Michelle Garfinkel, Stergios Skaperdas, and Ami Glazer for helping me get started on the first chapter of my dissertation; Dan Bogart for structuring a plan to navigate the Ph.D. program; Dave Whitney, Seiji Steimetz, and Yingying Dong for pedagogical mentorship; and of course, Katie Holland, Melissa Valdez, John Sommerhauser, and Jennifer Gerson for their endless logistical support.

I would like to acknowledge financial support from the School of Social Sciences, the economics department, and the Division of Teaching Excellence and Innovation at UCI.

Last but not least, thanks to Elsevier for allowing me to incorporate published work in my dissertation.

VITA

Kyle Kole

EDUCATION

Doctor of Philosophy in Economics **2022**
University of California, Irvine *Irvine, CA*

Master of Arts, Economics, with Distinction in Microeconomics **2017**
University of California, Irvine *Irvine, CA*

Bachelor of Science, Applied Mathematics **2016**
Bachelor of Arts, Economics, with Distinction **2016**
University of California, San Diego (*cum laude*) *La Jolla, CA*

Journal Articles

"Housing Vouchers Reduce Residential Crowding" **2022**
Journal of Housing Economics

TEACHING EXPERIENCE

Lecturer **2021**
California State University, Los Angeles *Los Angeles, CA*

Instructor **2018–2019**
Johns Hopkins Center for Talented Youth *Baltimore, MD; Hong Kong*

Teaching Assistant **2016–2021**
University of California, Irvine *Irvine, CA*

Teaching Assistant **2014–2016**
University of California, San Diego *La Jolla, CA*

FUNDING AWARDS

DTEI Fellows Program **2021**
Economics Research Fellowship **2020–2021**
BUILD Pre-Professorate Fellows Program **2021**

ABSTRACT OF THE DISSERTATION

Essays on Urban Economics

By

Kyle Kole

Doctor of Philosophy in Economics

University of California, Irvine, 2022

Distinguished Professor Jan Brueckner, Chair

This dissertation consists of three essays on urban economics. The first essay applies the concept of agglomeration economies to the firm using a theoretical model of worker interaction. Next, the second essay takes an empirical approach to evaluate the efficacy of the Section 8 Housing Choice Voucher program, the largest housing program in the United States of America, in addressing residential crowding across the nation. Finally, the third essay empirically investigates the effect of grocery stores on property values by analyzing the effects of the Food Retail Expansion to Support Health program in New York City. Each essay's conclusion comments on amenities and what influences them.

The first essay sheds light on why a firm would want to invest in its social infrastructure even if socializing is not directly related to productivity. Technological agglomeration economies are one reason for the existence of big cities, a common example being "cross-fertilization" that occurs when workers of different firms interact with each other. This "cross-fertilization" could be applied to workers in a specific firm, presenting a reason for a firm to invest in socializing at the workplace. A theoretical model of worker interaction shows that the socially optimal level of socializing is risk dominated by lower levels of socializing, even when socializing is beneficial for productivity. A profit maximizing firm recognizes the benefits to productivity and would prefer its workers to socialize more, at the socially optimal level.

Hence, greater profits from increased productivity drive the incentive for a profit maximizing firm to invest in the work environment.

The second essay evaluates the effectiveness of the Section 8 Housing Choice Voucher program in tackling the problem of residential crowding. Prior research shows that expanding the Section 8 Housing Choice Voucher program has varying price effects on different parts of the rental housing market. While recipients will certainly benefit from the added vouchers, there is ambiguity in the impacts on quality of life for non-recipients in the broader housing market. Excessive crowding in homes, dubbed overcrowding, is one measure of quality of life because overcrowding can lead to adverse outcomes such as stunted child development, adverse mental health, and an increased risk in spreading infectious diseases such as COVID-19. This paper makes use of an exogenous increase in the supply of Section 8 housing vouchers in a panel setting to ascertain the effectiveness of a program provided at the federal level in tackling housing overcrowding throughout the nation. Estimation of a linear probability model shows that adding vouchers reduces the incidence of overcrowding: a 10% increase in the supply of vouchers reduces the likelihood that a housing unit is overcrowded by 0.081 percentage points. The mechanism behind the effect is shown to correspond with anecdotes about overcrowding: households experiencing misfortune, financial difficulties, or other tenuous circumstances double-up with higher-income households. Hence, a voucher enables the troubled household to move into more suitable living arrangements.

The third essay explores the Whole Foods Effect. The effect of grocery stores on property values is difficult to establish because of the endogeneity between where people choose to live and where grocery stores choose to operate. This paper is the first to establish that nearby grocery stores are local amenities, leading to higher property values, by using the Food Retail Expansion to Support Health (FRESH) program in New York City. On average, a residential property located near a new grocery store experiences a 7.94% increase in value. An exploration of mechanisms indicates that opening more grocery stores not only

contributes a direct effect to the increase in property values through an improvement of local amenities, but that it also attracts and sustains complementary businesses such as restaurants, thereby leading to a further increase in property values through an indirect improvement of local amenities.

Chapter 1

Investments in Socializing at the Workplace

1.1 Introduction

The theory of the firm attempts to explain the existence and nature of the firm. One of the questions it seeks to answer is what drives different actions and performances of firms. Popular belief would attribute differences in performance to the social aspect of the company, its people, through possible technological agglomeration economies. Socializing is of particular interest because this type of interaction is not necessarily related to work: when explaining the existence of big cities, technological agglomeration economies operate through "cross-fertilization," when workers from different firms interact in places like restaurants, cafes, or bars. However, socializing can facilitate communication that promotes mutual learning and reduce the incidence of negative behaviors such as harassment. Whether socializing will improve productivity is unclear because on one hand, it is time taken away from productivity, but on the other hand, mutual learning or fewer negative interactions could improve

productivity.

The media has applauded Google for its positive work culture, citing it as a major reason for why its employees are so productive. A former senior vice-president of people operations at Google has reported to *Huffington Post* that a simple, welcoming greeting for a new member leads to a 15% increase in productivity over the next 9 months (Wright, 2017).[1] *Harvard Business Review* (*HBR*) provides an exposition on how firms suffer from the costs of its employees' lowered well-being (Burkus, 2017).[2] Stress leads to major health costs and propagates disengagement from work, leading to 18% lower productivity and 16% lower profitability. Half of the suggested solutions involve proactive socializing. By fostering social connections and encouraging people to talk about their problems, the firm observes greater performance, especially greater economic performance. Although socializing may seem to possess many benefits, another *HBR* article warns against the drawbacks associated with socializing: quality relationships require more energy to maintain, impromptu discussions and extended breaks consume time, and conversations about tenuous topics may quickly turn sour (Seppälä and Cameron, 2015).[3]

Conventional wisdom would suggest some socializing is beneficial in the workplace, but too much socializing becomes a problem (Smith, 2013).[4] What sort of factors determine the amount of socializing between workers? How can socializing be framed to reflect the firm's understanding of how socializing affects productivity? Are the firm's profits maximized if it permits an activity distinct from revenue-generating activities? This paper seeks to model socializing within a group production process to provide insight into why a firm would want to invest in an activity indirectly related to production. Specifically, this model will

[1] https://www.huffingtonpost.com/entry/10-things-to-know-about-googles-awesome-culture_us_59088802e4b03b105b44bbfd

[2] https://hbr.org/2017/05/work-friends-make-us-more-productive-except-when-they-stress-us-out

[3] https://hbr.org/2015/12/proof-that-positive-work-cultures-are-more-productive

[4] https://www.forbes.com/sites/jacquelynsmith/2013/09/24/how-much-coworker-socializing-is-good-for-your-career/#d50344151a06

examine how effort contributed to production, measured in time, depends on the structure of socializing.

A homogeneous partnership is used as a baseline to understand how socializing is determined in a group of workers. In equilibrium, workers will resolve the tension between benefits from socializing versus the cost of production and socializing. Socializing can be analyzed as a strategic interaction because time in the workplace is fixed, but how the worker chooses to allocate his time between working and socializing depends on how others choose to allocate their time. The Nash equilibrium is a tractable solution concept for a preliminary analysis of what sort of behaviors ensue, given different conceptualizations of how time is used in social interaction. Because the model focuses on a one-shot equilibrium, this is an analysis of workers avoiding repeated interaction once the production process concludes, even if in reality workers would like to continue working in the same teams.

An equilibrium is a consequence of individual preferences, but the individual might be unaware of the externalities his socializing imposes on his partner. To account for externalities and the welfare of the team as a whole, the equilibrium is compared to a socially optimal allocation of time. If there are positive externalities unaccounted for in the equilibrium, then the socially optimal level of socializing should be greater than that in equilibrium. The analysis also studies the firm's profit maximizing level of socializing to ascertain whether or not a firm would want to invest in fostering more socializing in its workers.

Models examining information structures in teams and peer effects exist.[5] Empirical work has shown positive and negative peer effects in various settings. These results often suggest peer effects are especially strong among peers who consider themselves friends.[6] The empirical

[5]See Marschak and Radner (1972) on teams and information structures. Holmstrom (1982) has provided an analysis of how to structure incentives to alleviate moral hazard in teams. Kandel and Lazear (1992) offer a model on peer pressure.

[6]Bandiera et al. (2005) find reduced productivity under a relative pay scheme, especially within groups of friends. Mas and Moretti (2009) notice that positive peer effects disappear if the addition of a highly skilled worker is unobservable to the rest of the team.

results suggest that socializing plays a larger role in determining the intensity of peer effects, but socializing has been elicited only through particular mechanisms such as a relative pay scheme.

The results of this model offer a preliminary analysis to the broader question of why a firm would invest in socializing at the workplace. To the best of my knowledge, no model specifically examines socializing among individuals or socializing from the firm's perspective. In this model, a firm is shown to find that making investments to address social barriers in the workplace can be profit maximizing as long as socializing possesses an indirect benefit to production. Workers might choose not to socialize at all if social barriers are too obtrusive. They will choose to allocate all of their time to socializing only if social barriers are not present, but this is not realistic because removing all social barriers could prove too costly for a firm. Furthermore, the model highlights how socializing is a coordination problem in which workers must agree on how much time should be spent on socializing. The firm making investments to reduce social barriers thus acts as a coordination device among workers.

The subsequent sections are outlined as follows: Section 1.2 examines the equilibrium from a homogeneous partnership, then it compares the equilibrium from a homogeneous partnership to their socially optimal allocation of time. Section 1.3 offers an alternative comparison to the socially optimal solution by solving for the firm's profit maximizing allocation of time, and finally Section 1.4 concludes.

1.2 Workers' Problem

Consider how workers will behave when given the choice to either spend time in production or socialize in the workplace. They are not concerned with maximizing profits for the firm. Rather, they are concerned with maximizing their own happiness in the workplace by

choosing how to spend their time. The model will take the perspective that workers are required to be present at work. Suppose the number of hours in the workplace is fixed at L. Many occupations which require teamwork reflect this assumption—e.g. farm labor in the case of Bandiera et al. (2005) and supermarket check-out stations analyzed by Mas and Moretti (2009). The wage structure is not of interest in this model, so the worker's wage w is assumed to be fixed such that the total pecuniary payoff does not factor into the individual worker's decision.

This model will make the assumption that workers are paired together in a homogeneous partnership. In a team production setting, this assumption commonly occurs by pairing similar workers with each other. Homogeneity refers specifically to identical preferences by assuming identical exogenous parameters. Assuming homogeneity helps to elucidate the interpretation behind each parameter. Furthermore, the equilibrium under homogeneity offers easily interpretable comparative statics. Any possible asymmetry will not be included, although intuition behind adding heterogeneity will remain clear.

Workers balance the benefits earned by socializing in the workplace against the costs of effort and socializing. Thus, the assumption of homogeneity implies that the workers, i and j, are identical in their costs and benefits because both are defined by identical exogenous constants. As mentioned earlier, they must each choose how to allocate time between working e and socializing s such that their time in the workplace is L. The number of hours in the workplace L is fixed, so any allocation of time satisfying the time constraint accounts for the opportunity cost of foregone socializing. The trade-off here is non-material payoffs from socializing versus costly effort and costly socializing. A fixed pecuniary payoff of wL is given to each worker to compensate for their time in the workplace. Utility for worker i is

$$U_i(e_i, e_j; s_i, s_j) = wL - \frac{1}{2}e_i^2 + S_i(s_i, s_j) \tag{1.1}$$

where $S_i(s_i, s_j)$ is worker i's measure of the net utility for socializing (j's utility is defined similarly). $S_i(s_i, s_j)$ captures two aspects of socializing: mutual interaction and costly maintenance of social interaction. Mutual interaction is limited by the extent to which the partner reciprocates. The one who decides to spend less time socializing chooses not to fully reciprocate the social advances made by the other party. That being said, the time spent in mutual interaction is costly to maintain because individuals possess a limited tolerance for emotionally taxing conversations, annoyances, and the social stigma associated with socializing in the workplace. In light of each worker's time constraint, $S_i(s_i, s_j)$ thus captures the net utility of spending time on activities clearly distinct from any work-related activities. Mutual learning and apprenticeships, for example, are not captured by this model because those interactions are not clearly distinct from work-related activities, but playing ping pong in the company rumpus room is captured by the model.

The worker takes as given the social barriers $\rho \geq 0$ between her and other workers. The firm addresses issues of socializing between workers by making investments into the social infrastructure to lower the social barriers they face. Examples of these investments range from tangible to non-tangible ones such as building a cafeteria, providing a company rumpus room, and fostering a friendlier environment. A larger ρ means the extent to which social barriers are present is greater. Essentially, the workers take as given any investments the firm has made. When only the minimum investment is made, workers face $\rho = \infty$, an infinite cost to socializing because the social barriers prevent any kind of socializing.

Let $\theta \geq 0$ represent the workers' affinity for socializing. Possessing an affinity for socializing represents the individual's opinion on socializing in the workplace, as well as any societal factors that might influence his value for socializing. A myriad of societal factors can influence θ: past experiences, culture, and political environment, just to name a few. However, to keep with a homogeneous model, the workers are assumed to have their affinity for socializing determined by commonly understood norms set in society. Social barriers come into direct

opposition to the workers' affinity for socializing. For now, the assumption that $\rho > \theta$ will be made to guarantee that no worker would choose to allocate all of her time in the workplace to socializing. Further details of where this assumption plays a key role is discussed after the equilibrium is derived.

Putting it all together, let the measure on the utility of socializing for i (j's is defined similarly) be specified as

$$S_i(s_i, s_j) = \theta \min\{s_i, s_j\} - \rho s_i \,. \tag{1.2}$$

wherein taking the minimum of s_i and s_j reflects mutual interaction and the second term reflects increasing costly maintenance of social interaction. Any convex cost function suffices to reflect increasing costs, but this particular functional form is chosen because it is conducive to producing an easily interpretable solution to the workers' problem. The full cost of the individual's decision to socialize is borne solely by the individual, so the equilibrium will reflect a version of a coordination game. Indeed, the cost of suffering social stigma is quite salient when choosing to "socialize" in excess of the partner. For instance, suppose $s_i > s_j$. The time spent up until s_j is the time worker i spends socializing with worker j. Any time in excess of s_j can be interpreted as worker i shirking because she is simply spending time in the recreation room, albeit alone. Shirking in the workplace comes at the cost of social stigma.

Even though the costs of choosing to "socialize" in excess of what the partner is willing to reciprocate might have already been implied by taking the minimum between s_i and s_j, the second term in $S_i(s_i, s_j)$ is essential to guarantee that spending all L hours socializing is not the unique equilibrium. If spending all L hours socializing were the unique equilibrium, the results of the model will not be very realistic because no firm can operate if its employees choose to only socialize at work.

Thus, because socializing requires mutual interaction, worker i would rather not choose to spend more time than worker j socializing, and vice versa. This will be key when solving for the Nash equilibrium levels of socializing in the homogeneous partnership. Note that the interaction between θ and ρ captures how a very advanced social infrastructure can induce modest benefits, even to those with a low value for socializing.

1.2.1 Equilibrium

To rigorously show that in equilibrium $s_i = s_j = s$, it must be shown that neither worker would want to unilaterally deviate. Consider i and j's respective utilities. In choosing their time allocations, both workers must ensure that their choices maximize their respective utilities. Worker i's constrained maximization problem is then

$$\begin{aligned} \underset{e_i, s_i}{\text{Max}} \quad & U_i(e_i, e_j; s_i, s_j) \;\; = wL - \frac{1}{2}e_i^2 + S_i(s_i, s_j) \\ \text{subject to} \quad & e_i + s_i = L\,. \end{aligned} \tag{1.3}$$

Worker j's problem is analogous. Utilities are symmetric for the partnership. Henceforth, only the analysis for worker i is shown because the analysis for worker j can be analogously described. The objective function in Equation 1.3 is re-written using the time constraint to reflect two distinct cases

$$U_i(s_i) = \begin{cases} wL - \frac{1}{2}(L - s_i)^2 + \theta s_j - \rho s_i, & \text{for } s_i > s_j \\ wL - \frac{1}{2}(L - s_i)^2 + (\theta - \rho)s_i, & \text{for } s_i \leq s_j\,. \end{cases} \tag{1.4}$$

Since her utility is continuous in her own choice of socializing, but not differentiable on the entire interval $(0, L)$, analyzing first order conditions might not result in every possible

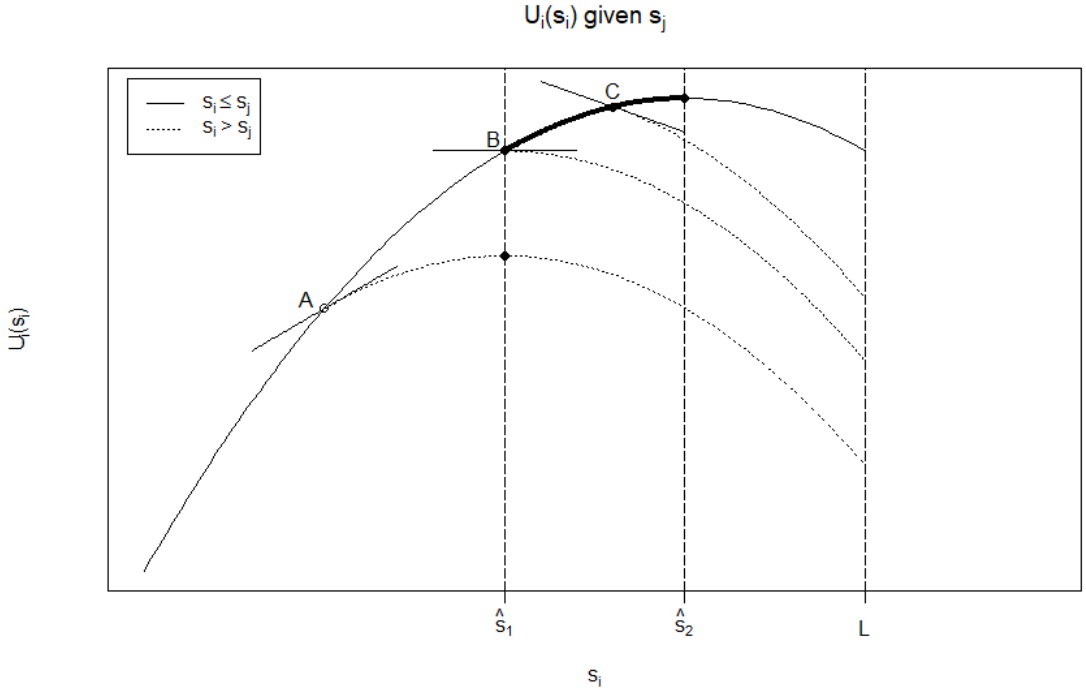

Figure 1.1: Worker i's Utility Given s_j

equilibrium. Therefore, it must be shown where worker i would not want to unilaterally deviate from choosing $s_i = s_j$.

A graph of $U_i(s_i)$ given particular values of s_j is shown in Figure 1.1. The solid line traces worker i's utility for when worker j chooses to allocate all L hours to socializing. The peak of worker i's utility on this solid line occurs at $\hat{s}_2 = L + \theta - \rho$. The selected points, A, B, and C, in this figure represent when worker j chooses an allocation of time different form L. For example, at point B, worker j chooses an allocation of time corresponding to $\hat{s}_1 = L + \theta$. Utility for worker i then follows the solid line before point B and the dotted line after point B. The specification of utility reflects what is in the figure: allocating time to socializing less than worker j is captured by graphing the utility in a solid line, and allocating time to socializing greater than worker j is captured by graphing the utility in a dotted line. This is repeated at points A and C.

Note that if worker j chooses a low level of socializing, then worker i's utility will largely follow the dotted parabola with peak at $\hat{s}_1 = L - \rho$. A tangent line to the dotted parabola at each specific point highlights the fact that there is a kink point when $s_i = s_j$. The utility is not differentiable at $s_i = s_j$ because the derivative from the left and the right are not the same:

$$\frac{\partial}{\partial s_i} U_i(s_i) = \begin{cases} (L - s_i) - \rho, & \text{for } s_i > s_j \\ (L - s_i) + (\theta - \rho), & \text{for } s_i \leq s_j \,. \end{cases} \tag{1.5}$$

There are three distinct regions that worker i must consider: $s_j < \hat{s}_1$, $\hat{s}_1 \leq s_j \leq \hat{s}_2$, and $s_j > \hat{s}_2$. Within each region, the argument for whether worker i would want to unilaterally deviate differs slightly. As can be seen from Figure 1.1, equilibria will exist only in the second region, $\hat{s}_1 \leq s_j \leq \hat{s}_2$.

Consider the first region in Figure 1.1 defined by $s_j < \hat{s}_1$. Point A demonstrates the analysis in this region. For $s_i \leq s_j$, worker i's payoff follows a region of the parabola up until point A, illustrated by the solid line. Beyond point A, $s_i > s_j$, so now worker i's payoff follows a different parabola illustrated by the dotted line. The tangent line drawn at point A shows that worker i would like to increase her level of socializing beyond s_j because she can positively gain from doing so. In fact, she will increase her level of socializing up until $\hat{s}_1$, the peak of the parabola traced by the dotted line. It is possible to solve for this generally: worker i would want to unilaterally increase her socializing away from the kink point (i.e., $s_i = s_j$) by $\epsilon > 0$ only when the difference in her utility is positive,

$$\begin{aligned} U_i(s_i + \epsilon, s_j) - U_i(s_i, s_j) &> 0 \\ (L - s_i)\epsilon - \frac{1}{2}\epsilon^2 - \rho\epsilon &> 0 \,, \end{aligned}$$

which results in a restriction on the given level of s_j for which this is possible,

$$s_j < L - \rho + \frac{1}{2}\epsilon\,. \tag{1.6}$$

Thus, worker i would want to unilaterally deviate by increasing her socializing by any sufficiently small $\epsilon > 0$ as long as the kink point is below a certain threshold defined by exogenous parameters and the magnitude of the desired deviation. Taking the limit as ϵ tends towards 0 results in the threshold beyond which worker i would not want to increase socializing

$$\lim_{\epsilon \to 0} L - \rho + \frac{1}{2}\epsilon = L - \rho \equiv \hat{s}_1\,. \tag{1.7}$$

The analysis for the second region defined by $\hat{s}_1 \leq s_j \leq \hat{s}_2$ is clear once the region for $s_j > \hat{s}_2$ has been analyzed. Thus, consider now when worker i must best-respond to any given $s_j > \hat{s}_2$. Figure 1.1 illustrates a trend: any choice of socializing beyond s_j for worker i will result in a lower payoff given any $s_j > \hat{s}_1$. This is in accordance with the equilibrium analysis up leading up to Equation 1.7. Worker i will therefore choose $\hat{s}_2$ for any $s_j > \hat{s}_2$ because $\hat{s}_2$ maximizes her payoff in that region. Proceeding in a similar fashion as before, this can be shown in generality by deriving when there exists an incentive for worker i to unilaterally deviate by decreasing her socializing, resulting in an analogous restriction,

$$\begin{aligned} U_i(s_i - \epsilon, s_j) - U_i(s_i, s_j) &> 0 \\ -(L - s_i)\epsilon - \frac{1}{2}\epsilon^2 - \rho\epsilon &> 0 \\ s_j &> L + \theta - \rho + \frac{1}{2}\epsilon\,. \end{aligned}$$

Again, taking the limit as ϵ approaches 0 gives the threshold below which worker i would not want to decrease her socializing

$$\lim_{\epsilon \to 0} L + \theta - \rho + \frac{1}{2}\epsilon = L + \theta - \rho \equiv \hat{s}_2 \,. \tag{1.8}$$

Thus far, two pure strategy equilibria have been shown to exist, but there could be more in the region between $\hat{s}_1$ and $\hat{s}_2$. Deriving the thresholds for where an incentive to unilaterally deviate also shows that neither worker would not want to increase or decrease their socializing away from the kink point for any kink point between $\hat{s}_1$ and $\hat{s}_2$, so any symmetric allocation of time within $[\hat{s}_1, \hat{s}_2]$ is an equilibrium. Consequently, there is a continuum of equilibria. Equilibrium payoff is the bolded portion of worker i's utility in Figure 1.1. Indeed, the payoffs for $(\hat{s}_1, \hat{s}_1)$ and $(\hat{s}_2, \hat{s}_2)$ can be found on the bolded portion.

These results are captured by plotting each worker's respective best response function in a square of length L. Figure 1.2 illustrates all possible symmetric equilibria in the set $\{(s^*, s^*) : s_i^* = s_j^* = s^* \,, \hat{s}_1 \leq s^* \leq \hat{s}_2\}$, represented by the bolded line where best response functions coincide for both workers.

Based on this analysis, the significance of assuming $\rho > \theta$ is now clear. If the firm provides sufficient investments such that the marginal cost of socializing, captured by the measure for social barriers, is less than its marginal benefit, then $L < \hat{s}_2$ so that (L, L) becomes a possible equilibrium allocation of time for socializing. Such an allocation of time in the workplace yields a nonsensical interpretation. Avoiding the possibility of a nonsensical equilibrium thus avoids possible nonsensical results from the model. Henceforth, it will be assumed that $\rho > \theta$. This restriction also affords a simple interpretation: workers will not spend all of their time socializing as long as there exist sufficient social barriers to keep them from doing so. Stated analogously, the firm must be careful not to over-invest in the social infrastructure else too many distractions will be available to its workers. Because socializing provides workers with

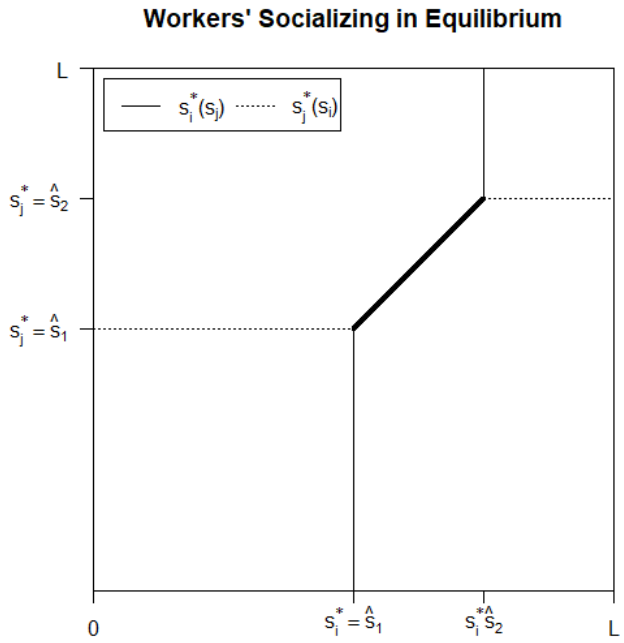

Figure 1.2: Equilibrium Socializing

additional non-material benefits, the concern is not whether they will socialize or not. Only if socializing is sufficiently costly will $(0, 0)$ be a possible equilibrium. However, this might not be profit maximizing for the firm, as will be seen later in Section 1.3.

Comparative Statics of the Interior Equilibrium

Comparative statics on each exogenous parameter are straightforward. Unfortunately, comparative statics make no comment on equilibrium selection, so their interpretations can only be applied to a discussion of the range of possible equilibria. A change in the number of work hours and social barriers produces a corresponding shift in the interval of possible equilibria. However, an increase in the affinity for socializing, θ, does not shift the interval, but instead lengthens it, because the length of the interval is θ. An increase in the length of the interval means as workers appreciate socializing more, the number of possible equilibria grows.

Choosing to allocate all work hours to socializing is a possible equilibrium only if $\hat{s}_2 < L$. This occurs when the condition $\rho > \theta$ fails to hold, meaning that there are not sufficient social barriers to discourage workers from spending all of their time socializing at work. Similarly, choosing not to socialize becomes a possible equilibrium if social barriers are too immense to overcome, $\rho > L$. It is theoretically possible for socializing to be so costly that the unique equilibrium is to choose not to socialize at all. Workers cannot influence the social barriers and take them as given. Because social barriers are inversely related to investments in social infrastructure, choosing not to socialize as a unique equilibrium essentially corresponds to the firm not making any investments in the social infrastructure. This will be discussed in more detail in Section 1.3.

Mixed Strategy Equilibrium

Infinite pure strategy equilibria exist for the homogeneous partnership. How about a mixed strategy equilibrium? One can imagine levels of socializing can vary according to exogenous factors such as the individual's mood and availability. With no standard approach to determining mood and availability on a daily basis, these exogenous factors can be seen as randomly affecting socializing. According to both workers' best-response correspondence, any level of socializing below $\hat{s}_1$ or greater than $\hat{s}_2$ are never-best-responses. Suppose worker j chooses a level of socializing below $\hat{s}_1$. Worker i always has an incentive to increase her socializing above worker j's choice by choosing $\hat{s}_1$. Likewise if worker j chooses a level of socializing greater than $\hat{s}_2$, worker i will always have an incentive to limit her socializing to $\hat{s}_2$. The unique best-response to any value chosen between $\hat{s}_1$ and $\hat{s}_2$ is to match the partner's level of socializing. Hence, neither worker will place a positive probability of playing any strategies outside of $[\hat{s}_1, \hat{s}_2]$.

Without loss of generality, suppose j chooses his amount of socializing, s_j, according to some continuous and differentiable distribution $G(s_j)$ over $\hat{s}_1$ and $\hat{s}_2$. In response to worker

j playing a mixed strategy, worker i will mix only among pure strategies that do equally well in response to worker j's mixing. Otherwise, because a mixed strategy yields a convex combination of payoffs, worker i placing a positive probability on any strategy that yields strictly lower payoff relative to the other strategies with positive probability will reduce her expected payoff. Thus for worker i to choose a mixed strategy in response to worker j's mixing, worker i must necessarily possess multiple best responses to worker j mixing according to $G(s_j)$. Maximizing worker i's expected utility will ascertain if this is indeed true. Worker i's expected utility is

$$E[U_i(s_i, s_j)|s_i] = wL - \frac{1}{2}(L - s_i)^2 - \rho s_i + \theta \int_{\hat{s}_1}^{s_j} s_j dG(s_j) + \theta \int_{s_j}^{\hat{s}_2} s_i dG(s_j)\,. \tag{1.9}$$

By Leibniz's rule, i's first order condition balances the marginal cost of effort and the marginal cost of socializing with the expected return to socializing:

$$\frac{\partial E[U_i(\cdot)|s_i]}{\partial s_i} = L - s_i - \rho + \theta[G(\hat{s}_2) - G(s_i)] = 0 \tag{1.10}$$

$$\tilde{s}_i = L + \theta[G(\hat{s}_2) - G(\tilde{s}_i)] - \rho\,. \tag{1.11}$$

Worker i's best response to worker j mixing according to $G(s_j)$ solves Equation 1.11. The solution to Equation 1.11 is a fixed point in the interval $[\hat{s}_1, \hat{s}_2]$. To show this, let $H(\tilde{s}_i) \equiv L + \theta[G(\hat{s}_2) - G(\tilde{s}_i)] - \rho$. $H(\tilde{s}_i)$ is certainly bounded as $\tilde{s}_i$ varies between $\hat{s}_1$ and $\hat{s}_2$ because $G(\tilde{s}_i)$ is a cumulative distribution which takes values between 0 and 1 on its support. The domain of $H(\tilde{s}_i)$ is also necessarily convex since it is a subset of the real number line. Because H maps a subset of the real line to itself, Brouwer's fixed point theorem is satisfied.

If this fixed point is unique, then it must be that worker i responds to worker j's mixing with

a pure strategy because there are no other levels of socializing on which worker i would place positive probability. The fixed point is indeed unique since rearranging Equation 1.11 results in $H(\tilde{s}_i) - \tilde{s}_i = 0$. On the left-hand side is a strictly monotonically decreasing equation, thus it is bijective. Hence, the equality is satisfied only at one point—precisely the fixed point. So in response to worker j mixing according to $G(s_j)$, worker i will respond with a unique pure strategy $\tilde{s}_i$.

Likewise, worker j would decide to deviate from playing a mixed strategy and respond with a pure strategy due to the concavity of his payoff around the kink point. It has been shown in the pure strategy equilibrium analysis that neither worker possesses an incentive to increase or decrease their socializing away from the kink point. Doing so leads to a strictly lower payoff. Then it must also be that placing any positive probability on any other level of socializing aside from $\tilde{s}_i$ will yield a lower payoff. Thus, worker j will never choose to mix in response to $\tilde{s}_i$. A similar argument holds for if worker i chooses a level of socializing according to any distribution. No individual will choose a mixed strategy, hence no mixed equilibrium exists. The following proposition summarizes the results from the workers' problem:

Proposition 1. *Suppose the worker faces costly effort and costly socializing.*

(a) Workers would like to socialize in a homogeneous partnership. The time spent socializing in equilibrium can take any value between $\hat{s}_1 = L - \rho$ *and* $\hat{s}_2 = L + \theta - \rho$ *as long as* $s_i^* = s_j^*$.

(b) Allocating all work hours to socializing is not a possible equilibrium as long as there exists sufficient social barriers $\rho > \theta$.

(c) If social barriers are too immense, $\rho > L$, *socializing might not be worthwhile at all and choosing not to socialize becomes a possible equilibrium.*

(d) An increase in affinity for socializing, θ, *lengthens the range of possible equilibria by increasing only* $\hat{s}_2$.

(e) An increase of δ in the number of hours in the workplace L or a decrease of δ in the social barriers shifts the entire range of possible equilibrium by δ.

(f) There is no mixed equilibrium in a homogeneous partnership.

1.2.2 Equilibrium Selection

The workers have been endowed with time in the workplace. How they choose to spend that time is determined by the the Nash equilibrium concept. Nash equilibrium requires the individual to know her partner's preferences and time endowment; not a far fetched assumption if teams of two are expected to work together. Such knowledge may come from mutual expectations for social behavior in the firm or passing along an introduction of sorts before initiating the production process.

Additionally, to make this an equilibrium, neither individual in the partnership would want to deviate from the agreed upon level of socializing because no unilateral deviation leads to a higher payoff. Lack of an incentive to deviate is largely driven by the fact that socializing can be enjoyed only as a mutual endeavor. One worker cannot spend more time "socializing" than the other. Activities that can be considered as "socializing" in excess of the other are attempts at social advances which are all rejected, or at the very least, do not lead to greater reciprocation. Lack of reciprocation can lead to increasingly greater time costs. Hence, "socializing" in excess of what the other party is willing to do is a costly endeavor. However, workers still want to socialize because it provides benefits that mitigate the cost of working. All of these aspects lead to a symmetric equilibrium in which both workers in the partnership agree on an amount of time dedicated to socializing.

There is an infinite number of possible symmetric equilibria, but in the model, there is no explicit coordination device for the workers to follow. One of the drawbacks of having many equilibria is the issue of equilibrium selection, and without making a coordination device

explicit, there is no way to definitively predict which equilibrium will occur in reality. To address this issue, the concepts of payoff dominance and risk dominance, as introduced by Harsanyi et al. (1988), will aid in selecting a plausible equilibrium.

Payoff Dominance

Payoff dominance refines the Nash equilibrium concept by taking into consideration only the equilibrium that is Pareto superior to all other possible equilibria. As the name suggests, an equilibrium is payoff dominant if no other equilibrium yields greater payoffs to either player. Multiple payoff dominant equilibria occur only if those equilibria yield the same payoffs. Finding the payoff dominant equilibrium in the workers' problem amounts to solving the social planner's problem.

Analyzing the problem from the social planner's perspective asks a different set of questions. Are the workers behaving in a way that the whole partnership is maximizing its well-being? If a social planner were to allocate their time endowments in a socially optimal way, how would this allocation compare to the individuals' allocation of their time? The social planner maximizes the sum of utilities U_p in the partnership taking into account each worker's time constraint

$$\begin{aligned} \underset{e_i,e_j,s_i,s_j}{\text{Max}} \quad & U_p = U_i + U_j = 2wL - \frac{1}{2}(e_i^2 + e_j^2) + 2\theta \min\{s_i, s_j\} - \rho(s_i + s_j) \\ \text{subject to} \quad & e_i + s_i = L\,, \\ & e_j + s_j = L\,. \end{aligned} \tag{1.12}$$

The social planner has no incentive to allocate time to socializing for one worker in excess of the other because the excess time will simply subtract from payoffs in the form of costs. What drives the social planner to choose a symmetric solution is the mutual interaction

aspect of socializing. Neither worker can benefit by spending more time "socializing" than her peer. Furthermore, once the social planner recognizes that maximizing the social welfare function requires a symmetric equilibrium, the problem ultimately reduces to deriving the time allocation for socializing because the time constraint for each worker is the same.

To formally show a symmetric solution to the planner's problem, the social welfare function is first written to reflect the time constraints for each worker

$$U_p(s_i, s_j) = \begin{cases} 2wL - \frac{1}{2}[(L - s_i)^2 + (L - s_j)^2] + 2\theta s_j - \rho(s_i + s_j), & \text{for } s_i > s_j \\ 2wL - \frac{1}{2}[(L - s_i)^2 + (L - s_j)^2] + 2\theta s_i - \rho(s_i + s_j), & \text{for } s_i \leq s_j \,. \end{cases} \tag{1.13}$$

Consider the case when $s_i > s_j$. The first order conditions with respect to s_i and s_j are

$$\begin{aligned} \frac{\partial U_p}{\partial s_i} &= (L - s_i) - s_i = 0 \\ \frac{\partial U_p}{\partial s_j} &= (L - s_j) + 2\theta - s_j = 0 \,, \end{aligned}$$

which yields the following socially optimal solution: $(s_i^* = \frac{1}{2}L, s_j^* = \frac{1}{2}L + \theta)$. However, the proposed solution contradicts the original assumption that $s_i > s_j$. A similar argument applies to the case when $s_i < s_j$.

Hence, just as in Section 1.2, the social planner can consider only symmetric solutions $e_i = e_j$ and $s_i = s_j$. Furthermore, because the time constraint is identical for both workers, maximizing the payoff to the partnership now simplifies to choosing only one variable—the level of socializing. The social welfare function, taking into consideration the time constraint, is now

$$U_p = 2wL - (L - s)^2 + 2\theta s - 2\rho s\,,$$

which yields the first order condition

$$\frac{\partial U_p}{\partial s} = 2(L - s) + 2\theta - 2\rho = 0\,. \tag{1.14}$$

The social planner must balance the benefits of socializing with the costs of effort and maintaining social connections. The first order condition derived from the social planner's problem given by Equation 1.14 yields $s_p^* = L + \theta - \rho$, coincidentally the same allocation of time as $\hat{s}_2$ in the workers' problem. Homogeneity in workers drives this result. The partnership benefits twice as much from socializing compared to the individual, but it also accounts for double the cost. To ensure that the interior solution is indeed a maximum, the first order condition evaluated at the corners must be such that

$$\left.\frac{\partial U_p}{\partial s}\right|_{s=0} = 2L + 2\theta - 2\rho > 0 \tag{1.15}$$

$$\left.\frac{\partial U_p}{\partial s}\right|_{s=L} = 2\theta - 2\rho < 0\,. \tag{1.16}$$

The same restriction, $\rho > \theta$, in Section 1.2 guarantees that the solution to the planner's problem is not to allocate all hours required in the workplace to socializing. A new restriction arises to ensure the same about choosing not to socialize in the workplace: $\rho < L$. Mathematically, the derivative found in Equation 1.14 exists because the function $U_p(s)$ is differentiable for all s, but attention is restricted to $s \in [0, L]$ in accordance with the model. Henceforth, the restriction $\theta < \rho < L$ will persist throughout the remainder of the paper so that there is a unique solution to the social planner's problem. This new restriction

thus eliminates the possibility of choosing not to socialize as an equilibrium in the workers' problem.

Since a Nash equilibrium coincides with that in the social planner's problem, externalities must have been accounted for even though the equilibrium is derived from individual preferences. Again, the mutual interaction aspect of socializing plays a key role. The only source of externalities between the workers is in the benefit to socializing. Using the case when $s_i < s_j$ as an example, j experiences a negative externality from socializing because any benefits he experiences are limited to the level of socializing that i chooses, although j's cost to socializing is not limited in a similar fashion. The full cost is still imposed on j. In fact, the magnitude of the negative externality can be calculated precisely as the absolute value in the difference in cost, $|s_i - s_j|$.

The externality disappears when the difference in cost disappears. This happens only when $s_i = s_j$. Because the Nash equilibrium results in a symmetric level of socializing, this condition is satisfied. In equilibrium, externalities are not present. The social optimum also requires that $s_i = s_j$, so externalities are also accounted for in the social optimum. Hence, since there are no externalities prompting any differences between the two, the equilibrium coincides with the social optimum.

By solving the social planner's problem, a unique payoff dominant equilibrium results. The planner's problem coincides with a payoff dominant equilibrium because the planner must maximize the sum of utilities. Since every term in the sum carries a positive weight, the maximization is equivalent to individually maximizing each term. Therefore each worker obtains her maximum payoff at the planner's solution, s_p^*, and this is equilibrium is Pareto superior to all other possible equilibrium.

Although this is by no means a rigorous proof, the payoff dominant equilibrium can be used to argue that this particular equilibrium level of socializing occurs in reality for two main

reasons: if workers are most interested in doing what is best for the team, and if these partnerships have persisted for a sufficiently long time. As hinted by the solution to the planner's problem, the welfare of the team is maximized at the payoff dominant equilibrium. A team-oriented sentiment is possible if these partnerships are formed in an environment that emphasizes teamwork, such as the military. If these workers have the interests of the team at heart, then it is certainly plausible for them to coordinate on the payoff dominant equilibrium.

Concerns for the team as a whole is also possible if these workers have been working together for a lengthy period of time. Even though the setup of this model is a one-shot game, it is well known that individuals may cooperate on the payoff dominant equilibrium in an infinitely repeated setting under certain conditions. This also reinforces the notion of how preferences might become common knowledge to those in the partnership. Even so, common knowledge can lead to an alternative equilibrium, as shown by risk dominance.

Risk Dominance

Risk dominance and payoff dominance typically select different equilibria in games with coordination problems. In opposition to partnerships that have worked together for some time, new partnerships might be plagued with uncertainty regarding how much the partner would like to socialize. Such uncertainty arises through the same logic given when motivating the mixed strategy equilibrium: external factors that can be seen as random have influence on the level of socializing chosen at any particular moment in time. If so, the worker would rather choose a level of socializing that is safe in the face of uncertainty. This "safe" strategy is the risk dominant strategy.

Particular to this setting, suppose there are two symmetric Nash equilibrium (s, s) and (s', s') such that $s < s'$. Then s is pairwise risk dominant for the partnership if the squared product

of deviations from s is greater than that of s'

$$[U_i(s',s) - U_i(s,s)]\,[U_j(s',s) - U_j(s,s)] \geq [U_i(s,s') - U_i(s',s')]\,[U_j(s,s') - U_j(s',s')]\ . \tag{1.17}$$

A further simplification can be made since payoffs in the worker's problem is symmetric:

$$[U(s',s) - U(s,s)]^2 \geq [U(s,s') - U(s',s')]^2\ . \tag{1.18}$$

In fact, in the worker's problem, any s such that $s < \hat{s}_2$ risk dominates $\hat{s}_2$. This result relies on the fact that decreasing or increasing socializing away from the kink point results in a lower payoff for either worker,

$$\begin{gathered}
[U(s',s) - U(s,s)]^2 \geq [U(s,s') - U(s',s')]^2 \\
U(s',s) - U(s,s) \leq U(s,s') - U(s',s') \\
\hat{s}_1 + \hat{s}_2 \leq s + s'\,,
\end{gathered}$$

where $\hat{s}_1$ and $\hat{s}_2$ are the same as before. The inequality certainly holds for any $s < \hat{s}_2$ if $s' = \hat{s}_2$. Despite being payoff dominant, $\hat{s}_2$ is risk dominated by every other equilibrium. Namely, without loss of generality, it is risk dominated by $\hat{s}_1$. To the individual worker, choosing a level of socializing in excess of her partner is too costly versus choosing to socialize less than her partner. If uncertainty is prevalent among the partnerships, then every worker would rather choose to socialize a little as possible. Risk dominance implies a sentiment of conformity and docility in the workplace: no worker would want to suffer the social stigma

of being a shirker. These results are summarized in the following proposition

Proposition 2. *Refine the infinite equilibria according to payoff dominance and risk dominance*

(a) Externalities are not present in equilibrium.

(b) The payoff dominant equilibrium coincides with the solution to the social planner's problem, $s_p^* = \hat{s}_2 = L + \theta - \rho$.

(c) Every other equilibrium pairwise risk dominates the payoff dominant equilibrium. In particular, $\hat{s}_1 = L - \rho$ *risk dominates* $\hat{s}_2$.

1.3 Firm's Problem

Applying payoff dominance and risk dominance narrows the possible equilibria down to two possibilities, but so far, the firm has yet to play a role in determining the equilibria aside from providing investments into social infrastructure that determine the social barriers, ρ. Is it profit maximizing for the firm to invest in something not directly related to production? Consider the problem of socializing from the standpoint of a firm whose goal is to maximize its profits. The firm can only influence its employees' behavior by setting the required number of hours at work and investing in the social infrastructure. Thus, it takes as given the equilibrium socializing that occurs in partnerships.

Production within the firm occurs in a team production setting. Suppose the firm examines the partnership of the two workers, i and j, wherein the workers are homogeneous in ability, α. Ability captures idiosyncratic characteristics for each worker. For instance, α captures the creativity, motivation, and proficiency of the worker. The assumption of homogeneity in ability will make a first-pass analysis easily tractable, but the assumption is not far removed

from reality. It is possible that the firm matches workers of similar ability, or that workers self-select themselves to be with someone of similar characteristics. Ability augments the worker's efforts in production, so for simplicity, assume that $\alpha \geq 1$. How workers behave in the firm is the same as in Section 1.2: each worker in the homogeneous partnership is required to work a fixed L number of labor-hours, is paid a fixed wage w, and both workers must choose between effort in production or time spent socializing such that their time constraint is satisfied.

The firm receives a fixed price p for each unit produced. Total revenue is then $pF(e_i, e_j; s_i, s_j)$, where $F(e_i, e_j; s_i, s_j)$ represents the production function, which will be explained in further detail momentarily. Moreover, the firm incurs an investment cost to lower social barriers by developing social infrastructure, represented by $I(\rho)$. Recall from Section 1.2 that workers view ρ as a measure of social barriers that affect their cost of socializing. The investment cost depends on the magnitude of ρ. To a firm, a more elaborate social infrastructure is more costly to maintain. Costs decrease with an increase in ρ since a larger ρ means a less elaborate social infrastructure. High social barriers prevail if a firm does not make investments to lower them. Depending on its specification, this function captures both fixed costs and variable costs associated with the investments. An example of social infrastructure is a cafeteria. One of Google's justifications in applying machine learning to optimize lunch lines is that there is a sweet spot for socializing: longer wait times mean employees are idling, but any shorter, then employees cannot initiate a substantial conversation. The investment cost results from building, supplying, and maintaining the cafeteria, and with these investments, workers face lower costs to socializing by taking advantage of these facilities. However, a firm cannot eliminate all social barriers, and not all developments in social infrastructure are equally effective

$$\frac{\partial I(\rho)}{\partial \rho} < 0 \tag{1.19}$$

$$\frac{\partial^2 I(\rho)}{\partial \rho^2} > 0\,. \tag{1.20}$$

Assume a basic level of investment is always made by the firm by imposing

$$\lim_{\rho \to \infty} I(\rho) = 0 \tag{1.21}$$

$$\lim_{\rho \to 0} I(\rho) = \infty\,. \tag{1.22}$$

Putting everything together, the firm's profit maximization problem is thus

$$\underset{L,\rho}{\text{Max}} \quad \pi(e_i, e_j; s_i, s_j) = pF(e_i, e_j; s_i, s_j) - wL - I(\rho) \tag{1.23}$$

Regarding the production function, the firm recognizes that socializing can be beneficial to production, but it might not understand specifically how. Suppose socializing benefits the employee by promoting creativity, learning from peers, and increasing motivation to accomplish work. Such a sentiment is evidenced again by Google: a former vice-president in Google's People Analytics department has stated that a simple, welcoming greeting on the first day of work has shown to increase productivity by 15%. *Harvard Business Review* has suggested the same. The firm's production process is specified to reflect how socializing can influence ability

$$F(e_i, e_j; s_i, s_j) = (\min\{s_i, s_j\} + \alpha)(e_i + e_j) \tag{1.24}$$

Because the partnership is homogeneous in ability, the benefits that socializing adds can be taken as a common factor that augments aggregate effort. The minimum between i and j's socializing is taken here to reflect that direct, mutual interaction is required to facilitate mutual learning, transfer of ideas, or motivational conversations. If one side chooses to refrain from conversation, then the extent of the mutual interaction is limited to just that. Thus, the extent of the benefit to ability α is also limited by mutual interaction. If no socializing occurs, then the production function captures individual production because it will depend solely on the individual amount of time each worker dedicates towards production. This scenario is possible if at least one of the workers wishes not to interact with her partner, so this production function is flexible enough to also capture individual production.

If the firm were to consider the workers' time constraints, it can examine the production function all in terms of work effort,

$$F(e_i, e_j) = \begin{cases} (L - e_i + \alpha)(e_i + e_j), & \text{for } e_i > e_j \\ (L - e_j + \alpha)(e_i + e_j), & \text{for } e_i \leq e_j \,. \end{cases} \tag{1.25}$$

Calculating the marginal product for each worker gives

$$\frac{\partial F(\cdot)}{\partial e_i} = \begin{cases} L + \alpha - 2e_i - e_j, & \text{for } e_i > e_j \\ L + \alpha - e_j, & \text{for } e_i \leq e_j \,, \end{cases} \tag{1.26}$$

$$\frac{\partial F(\cdot)}{\partial e_j} = \begin{cases} L + \alpha - e_i, & \text{for } e_i > e_j \\ L + \alpha - 2e_j - e_i, & \text{for } e_i \leq e_j \,. \end{cases} \tag{1.27}$$

Depending on how i and j socialize, the productivity of each worker differs. The worker who chooses to spend less time socializing influences both her own and her partner's productivity.

An increase in her effort will detract not only from her marginal productivity, but also from her partner's (recall that there are no externalities only when both workers choose the same level of socializing). Marginal products differ depending on who chooses to socialize less. Using the time constraint once more to re-write the marginal productivity for worker i, without loss of generality, shows that socializing can mitigate the negative effects that increasing effort might have on marginal productivity

$$\frac{\partial F(\cdot)}{\partial e_i} = \begin{cases} s_i + \alpha - e_i - e_j, & \text{for } e_i > e_j \\ L + \alpha - e_j, & \text{for } e_i \leq e_j \,. \end{cases} \tag{1.28}$$

This certainly fits the idea that socializing ameliorates disengagement in the workplace by reducing stress.

The firm takes as given the equilibrium level of socializing upon which workers agree in their partnership. There is a continuum of possible equilibria, so analyzing the firm's response will be restricted to looking only at those equilibria that reasonably occur. Furthermore, because the payoff dominant and risk dominant equilibria are characterized by parameters in the model, they offer a tractable solution to the firm's profit maximization problem.

Payoff Dominant Socializing

Suppose the workers choose the payoff dominant equilibrium, given by $\hat{s}_2 = L + \theta - \rho$. In response to their choice, the firm must maximize its profits by choosing the required number of hours at work and the targeted level of social barriers, which also determines the targeted level of investments the firm will make into the social infrastructure,

$$\underset{L,\rho}{\text{Max}} \quad \pi(L, \rho) = 2p(L + \theta - \rho + \alpha)(\rho - \theta) - wL - I(\rho) \,. \tag{1.29}$$

The firm's first order conditions requires the firm to balance its marginal revenues from labor hours with the marginal cost of investments and wages.

$$\frac{\partial \pi}{\partial L} = 2p(\rho - \theta) - w = 0 \tag{1.30}$$

$$\frac{\partial \pi}{\partial \rho} = 2p(\theta - \rho) + 2p(L + \theta - \rho + \alpha) - I'(\rho) = 0\,. \tag{1.31}$$

The first order condition given by Equation 1.30 immediately results in an optimal choice of social barriers $\rho_2^* = \frac{1}{2p}w + \theta$. This leads to an optimal choice of work hours required,

$$L_2^* = \frac{1}{2p} I'(\frac{1}{2p}w + \theta) + \frac{w}{p} - \alpha\,.$$

The subscript 2 simply refers to the fact that these maximizers are chosen given workers choose their payoff dominant equilibrium, $\hat{s}_2$. Even though price and wages are exogenously determined, a few assumptions must be made so that the resulting optimization makes sense. First, the results depend on the ratio between price and wages. Thus, normalizing the price to 1 consequently requires that wages must be sufficiently high to guarantee $\hat{s}_2 > 0$. Plugging in the firm's choice for L_2^* and ρ_2^* results in the constraint $w > 2\alpha - I'(\frac{1}{2}w + \theta)$ (recall that $I' < 0$ so that the difference is actually positive). This constraint will also ensure that $\hat{s}_2 < L$. Moreover, because the measure of social barriers must be positive, $w > 2\theta$. The interpretation behind both restrictions is that wages must be sufficiently high, but because the wage structure is not of interest, it will simply be assumed that wages satisfy these constraints.

Risk Dominant Socializing

Suppose instead workers choose the risk dominant equilibrium, given by $\hat{s}_1 = L - \rho$. The firm repeats the process of maximizing its profits by choosing L and ρ,

$$\underset{L,\rho}{\text{Max}} \quad \pi(L,\rho) = 2p(L-\rho+\alpha)(\rho) - wL - I(\rho)\,. \tag{1.32}$$

The interpretation of the first order conditions remains the same: the firm must set its marginal revenues equal to its marginal costs.

$$\frac{\partial \pi}{\partial L} = 2p\rho - w = 0\,, \tag{1.33}$$

$$\frac{\partial \pi}{\partial \rho} = -2p + 2p(L-\rho+\alpha) - I'(\rho) = 0\,, \tag{1.34}$$

which yields $\rho_1^* = \frac{1}{2p}w$, and $L_1^* = \frac{1}{2p}I'(\frac{1}{2p}w) + \frac{w}{p} - \alpha$, where the subscript 1 simply denotes that these values are derived by the firm's maximization problem in response to $\hat{s}_1$. Just as with analyzing the firm's response to the payoff dominant equilibrium, wages must be sufficiently large if price is normalized to 1 for these results to have meaningful interpretations. The only change from the restrictions before is $w > 2\alpha - I'(\frac{1}{2}w)$ since the second derivative of I is positive, but I' is negative.

Comparison of Equilibria

The firm's response to any equilibrium chosen by the workers constitutes a subgame perfect equilibrium. The first stage belongs to the firm which determines L and ρ through its profit maximization and in the second stage, workers solve a simultaneous move game given L and

ρ. Hence, there are two subgames: both stages as a whole, and a one-shot, simultaneous move game that constitutes the worker's problem. Infinitely many possible equilibria result from the latter subgame to which the firm replies with its best-response. The firm's best-response is given by the first order conditions to its profit maximization. Under certain assumptions on wages, the profit maximization admits a unique interior solution that, combined with the worker's equilibrium, forms the subgame perfect equilibrium.

Restricting the analysis to considering only the workers' payoff dominant equilibrium and one of their risk dominant equilibrium allows for a comparison of equilibrium results. It is straightforward to see that

$$\begin{aligned} \pi^*(L_1^*, \rho_1^*) &< \pi^*(L_2^*, \rho_2^*) \\ I\left(\frac{1}{2}w\right) &> I\left(\frac{1}{2}w + \theta\right), \end{aligned}$$

since investment costs is decreasing in ρ. Thus, the firm would prefer the workers select their payoff dominant equilibrium because it is also payoff dominant for the firm. Interestingly, it is payoff dominant for the firm because the workers can bear greater social barriers by dedicating more time to socializing. In fact, the firm acts as a coordination device by bringing the workers' payoff dominant and risk dominant equilibria closer together as long as the investment cost function is not extremely curved:

$$\begin{aligned} \hat{s}_2^* - \hat{s}_1^* &< \theta\,, \\ I'\left(\frac{1}{2}w + \theta\right) - I'\left(\frac{1}{2}w\right) &< \theta\,, \\ I''\left(\frac{1}{2}w\right) &< \theta\,. \end{aligned}$$

Note that with any subsidy which decreases the marginal cost of investments, the firm will decide to increase only the number of required work hours, L. As L increases, the workers likewise increase their socializing by a corresponding amount. Profits increase since the marginal profits with respect to L is always positive assuming wages are sufficient, and the workers' utility increases because their chosen level of socializing is now closer to the payoff dominant equilibrium before a subsidy. Any subsidy therefore improves the well-being of both the firm and workers. The following summarizes the results

Proposition 3. *Suppose the firm chooses the number of hours required in the workplace L and the level of investments in social infrastructure.*

(a) By maximizing profits in response to the workers' risk dominant equilibrium, the firm chooses $L_1^* = \frac{1}{2p}I'(\frac{1}{2p}w) + \frac{w}{p} - \alpha$ and $\rho_1^* = \frac{1}{2p}w$.

(b) By maximizing profits in response to the workers' payoff dominant equilibrium, the firm chooses $L_2^* = \frac{1}{2p}I'(\frac{1}{2p}w + \theta) + \frac{w}{p} - \alpha$ and $\rho_2^* = \frac{1}{2p}w + \theta$.

(c) For the results to all be positive, wages must be sufficient $w > 2\alpha - I'(\frac{1}{2}w) > \theta$.

(d) The firm prefers workers choose their payoff dominant equilibrium. By reducing the difference between the workers' payoff dominant and risk dominant equilibria, the firm can act as a coordination device.

(e) Any subsidy that reduces the marginal investment costs is welfare improving for the firm and workers.

1.4 Conclusion

Socializing is an activity that workers desire in a workplace because it can reduce feelings of disengagement, make mundane work more tolerable, and reduce overall stress. In a partnership, the amount of time devoted to socializing critically depends on the partner reciprocating and the benefits of socializing. The benefits are influenced by the firm through investments in the social infrastructure. Even though socializing is recognized to be beneficial to production, a firm would still rather its workers take the initiative themselves to socialize instead of relying on the firm's investments. Socializing can be costly to a firm, but given a sufficient amount of time in the workplace and the appropriate social infrastructure, an ideal mix of production and socializing can be realized by the workers such that their well-being and the firm's profits are maximized. Furthermore, any subsidy given to develop social infrastructure in the firm improves the well-being for the firm and workers.

Future work include introducing heterogeneity into the model to ascertain whether results hold outside of homogeneity. What is also interesting is exploring the various mechanisms a firm can take to influence its worker's socializing. In addition to providing physical infrastructure, a firm could provide social functions as a service to its workers. Other specifications of socializing may also lead to interesting results, especially considering certain policies firms enact to influence socializing. For example, Google requires an all-hands meeting on Mondays rather than at the end of the week. As with any theoretical model, it is desirable to seek empirical results to test the model and inform future theoretical work. It would certainly be desirable to measure the effects of socializing on productivity in the workplace, or even the effect of a change in social infrastructure and its effects on productivity.

Chapter 2

Housing Vouchers Reduce Residential Crowding

2.1 Introduction

Overcrowding is linked to stunted child development, adverse mental health, and the spread of disease, yet nearly 4 million households are considered overcrowded according to the 2015 American Community Survey.[1] Overcrowding arises in part from financial difficulties in affording an adequate living space. The Section 8 Housing Choice Voucher program provides housing vouchers that directly address the issue of financial difficulty, but these housing vouchers are not directed specifically towards households living in overcrowded situations. Coupled with a recent study finding that certain parts of the rental market experience increases in price in response to an increase in the supply of housing vouchers (Eriksen and Ross, 2015), potentially placing even more financial strain on households, the effectiveness of vouchers as a solution to overcrowding is ambiguous.

[1] Evans (2006) and Ferguson et al. (2013) provide a review of the overcrowding literature.

This paper seeks to ascertain the effectiveness of housing vouchers in tackling housing overcrowding by exploiting an exogenous increase in the supply of Section 8 housing vouchers between 2000 and 2002. The main findings show that housing vouchers reduce the likelihood that a housing unit is overcrowded. Computation of the elasticity suggests that a 10% increase in the supply of housing vouchers leads to an average reduction of 0.081 percentage points in the probability that a housing unit is overcrowded. Stated differently, an additional 595 housing vouchers alleviates overcrowding in 69 homes. Stratifying the data by household income and tenure suggests that vouchers address overcrowding by enabling recipients who have doubled-up with higher-income households to move into more suitable living arrangements. By exploiting the timing of vouchers granted through federal programs to public housing agencies, as measured by Eriksen and Ross (2015), the causal effect is identified through a fixed effects panel regression. Specifically, a linear probability model uses individual housing unit observations to regress a dummy that takes a value of 1 if the unit is overcrowded on the supply of housing vouchers measured at the metropolitan statistical area (MSA) level.

The main contribution of this study is the evaluation of a nationwide housing assistance program in addressing the issue of overcrowding in the broader housing market rather than only in the population eligible to receive assistance. There is extensive research on housing vouchers and their effects on broader housing market outcomes. Notably, Susin (2002) concludes that housing vouchers raise rents for low-income housing, but this conclusion has been subject to critique concerning unobserved housing characteristics that are correlated with the supply of vouchers (Olsen, 2003). Eriksen and Ross (2015) build on Susin (2002) by using a panel of housing units to address the endogeneity issues, finding that increases and decreases in rents are observed depending on the segment of the rental housing market to which the housing unit belongs. Because different segments of the rental housing market experience different shifts in rent, the overall effect on outcomes associated with quality of life, such as overcrowding, is ambiguous. Sinai and Waldfogel (2005) use cross-sectional

data to argue that housing assistance reduces the incidence of overcrowding. This paper expands on Sinai and Waldfogel (2005) by using panel data to argue that housing assistance, specifically vouchers, reduces the incidence of overcrowding.

Researchers have long been interested in the direct effects of housing assistance on recipient households. Popular outcomes of interest include school outcomes (Currie and Yelowitz, 2000; Horn et al., 2014), economic self-sufficiency (Kling et al., 2007), and general well-being (Katz et al., 2001). In relation to overcrowding, Currie and Yelowitz (2000) use an IV strategy to conclude that public housing reduces overcrowding. Although their focus is not on vouchers in particular, their results could suggest that housing assistance, irrespective of its form, alleviates overcrowding for recipients. However, there remains the question of whether housing assistance is able to address over-crowding in the broader housing market. For a recent review of the literature related to housing vouchers, see Ellen (2020).

Previous studies focusing on overcrowding generally test the effect of overcrowding on various outcomes, rather than the effect of interventions on overcrowding. For example, Goux and Maurin (2005) exploit differences in children's living conditions to identify the effect of overcrowding on school performance. Their results show that children living in overcrowded homes are more likely to be held back one grade. As such, overcrowding is a factor associated with negative school outcomes and many other concerns (Evans, 2006). When planning interventions, overcrowded living environments could be a possible tag for public assistance that is blind to individual demographics. However, before overcrowding is used as a tag in lieu of or in tandem with more popular tags such as income, there remains the question of how effective an existing public program like housing vouchers is in dealing with overcrowding.

An outline of this paper is as follows: Section 2.2 discusses the background behind over-crowding and the Section 8 Housing Choice Voucher program, Section 2.3 describes the data and empirical strategy, Section 2.4 reports the main results, Section 2.5 expands on the findings to determine mechanisms driving the main results, and Section 2.6 concludes.

2.2 Background

Although information on the voucher program's history and eligibility criteria is widely available, information on how vouchers are supplied and distributed is much more difficult to find. Moreover, overcrowding is a nebulous concept that has persisted in the discussion of housing needs for a long time, but the literature still finds difficulties in defining the phenomenon in a systematic and consistent fashion. This section clarifies what this paper considers as overcrowding, provides a description of how the voucher program operates, and details the plausible exogenous shock to housing vouchers.

2.2.1 Overcrowding

Overcrowding is a difficult concept to measure because it involves a bit of subjectivity. The purely objective measure, crowding, describes the density of people within the immediate surroundings, as opposed to population density, which describes the density of people over a wide geographic area (Abbott, 1982). Crowding is easily measured in an objective fashion, such as people per square foot or people per room, but the term overcrowding implies a threshold above which crowding has been deemed to have negative consequences. Researchers have historically been interested in overcrowding for reasons related to the spread of disease. A comprehensive review of this literature asserts that population density, such as people per acre, generally has little to no relation to health, whereas crowding exhibits a relationship (Evans, 2001). Several reviews point to people per room as the most consistent measure used in the literature (Evans, 2006; Blake et al., 2007; Ferguson et al., 2013). One of the most convincing studies using people per room is Goux and Maurin (2005). They construct and estimate a structural model by instrumenting for people per room using parents' birthplaces and the gender difference between the two eldest siblings. Their results show that children

living in more crowded spaces are 16.6 percentage points more likely to be held back one grade.[2]

The US Census defines overcrowding as greater than 1 people per room (PPR), and severe overcrowding as greater than 1.5 PPR. Under the PPR definition, the 2000 Census estimates that out of 105.5 million occupied homes, 5.7% of them (roughly 6 million) are overcrowded. Nonetheless, other thresholds exist, such as greater than 2 people per bedroom (PPB), and less than 165 square feet per person (SQFTPP). A discussion of these thresholds and works related to each of them is provided by a United States Department of Housing and Urban Development (HUD) study on overcrowding (Mills et al., 2006). The analysis presented in this paper remains agnostic as to which threshold best defines overcrowding because it cannot distinguish the effects of different levels of crowding on, for instance, health. Nevertheless, the analysis attempts to establish a relationship between the supply of housing vouchers and overcrowding based on all three definitions.

In terms of the adverse effects of overcrowding, observational studies mainly contribute to the body of evidence linking overcrowding with child development and mental health. One notable study, Evans et al. (1999), observed 42 midwestern American families each month over a period of 2.5 years. They find that as PPR increases (the dwelling becomes more crowded), parents begin to respond less to their children and use less sophisticated language. Hence, they claim to have found a plausible mechanism explaining the poor cognitive development in infants and children aged 5–10 that live in crowded environments, a connection that has been documented in several studies. The adverse effects are not limited to children: an experiment by Lepore et al. (1991) randomized undergraduate students into on- and off-campus housing. It concludes that longer exposure to overcrowding, as measured

[2]Goux and Maurin (2005) argue that families with similar financial constraints are more willing to crowd if the children are of the same gender and if the parents are from an urban background. By instrumenting for people per room using the children's gender difference and parents' backgrounds, they conclude that overcrowding adversely affects school performance. The most reasonable mechanism, among others, between overcrowding and school performance is an overall lack of financial means since families would typically prefer not to crowd if they can afford more housing.

by people per room, leads to stronger negative reactions to social hassles and lower perceived social support.

COVID-19 has called new attention to residential overcrowding. Officials highly recommend adhering to social distancing guidelines to stem the spread of COVID-19, but social distancing becomes increasingly difficult when the household lacks the space to do so. Coupled with stay-at-home orders, which lead to more close contact with members of the household, the risk of being infected in an overcrowded home certainly increases, putting the residents and the community at large in danger. This correlation has been documented in pregnant women living in New York City between March and April 2020 (Emeruwa et al., 2020). Population density is remarkably found not to be statistically significant in association with COVID-19 infection, whereas overcrowding is statistically significant. This finding suggests that overcrowding has a more prominent role to play in the spread of disease. Overall, a plethora of studies documents an association between overcrowding and stunted child development, adverse mental health, and increased risk of spreading harmful diseases. For a comprehensive summary of all these studies, see Evans (2006) and Ferguson et al. (2013).

In regards to the determinants of overcrowding, differences in culture (Myers et al., 1996; Burr et al., 2010; Burr and Mutchler, 2012), a lack of financial means, and misfortune are often cited as reasons for crowding into a home (Mills et al., 2006). Housing voucher recipients reveal in detailed interviews conducted by Mills et al. (2006) that they choose to double-up with friends or relatives mainly because of job loss, the birth of a new child, health complications, substance abuse, or a family break-up. Thus, if a lack of financial means is a major determinant of overcrowding, then housing vouchers have the potential to alleviate the problem because they provide the recipient with financial relief. As a caveat, Eriksen and Ross (2015) have shown price shifts in the rental market in response to an increase in the supply of housing vouchers: monthly rents increase for medium-quality rental units (those charging within 20% of the fair market rent, FMR) whereas low-quality rental units (those

charging less than 80% of the FMR) experience a decrease in monthly rent. Some households could be forced to downgrade in response to a heavier financial burden, but the cheaper, low-quality unit is likely to be a mismatch for the household's spatial needs because such units presumably did not sufficiently appeal to the household when initially searching for housing. How well vouchers broadly address the issue of overcrowding is therefore unclear. This paper will be the first to evaluate the effectiveness of housing vouchers in addressing housing overcrowding using a causal framework.

2.2.2 Housing Choice Voucher Program

The Section 8 program began in 1974 and went through major revisions up until 1998, when it was renamed the Housing Choice Voucher (HCV) program. Because of its origins, the program is still commonly referred to as Section 8 Housing Vouchers. It was the first housing aid program to target the demand-side of housing. All previous housing aid programs focused on the supply of housing by providing, for instance, public housing units. To date, the HCV program is HUD's largest housing aid program. $21 billion funded this tenant-based rental assistance program in 2018 alone, while $22 billion was requested for fiscal year 2020 to subsidize approximately 2.3 million low-income families. Vouchers are attractive for their cost-effectiveness and for flexibility in allowing recipients to choose their residence in the private housing market (Olsen, 2003).

A household is eligible to receive a voucher if it is classified as very low-income by HUD. HUD classifies households based on income limits that are calculated each year for every metropolitan area and non-metropolitan county based on median family incomes. This limit is referred to as the Area Median Income (AMI). Given its location, a household is considered low-income if it falls below 80% of the AMI, very low-income if below 50%, and extremely low-income if below 30%. AMI is adjusted for family size, and the year-to-year change is

capped above and below to avoid disruptions in the operation of the HCV program.

If a household is considered to be very or extremely low-income, it can apply for a housing voucher at its local Public Housing Agency (PHA). Although any eligible household can apply, there is typically a waitlist so that receipt of the voucher is not an entitlement. The waitlist is a result of a limited supply of housing vouchers. Occasionally, if the demand far exceeds the supply of vouchers, the PHA can close the waitlist until further notice. The National Low Income Housing Coalition reports that in 2016, the median wait time for a voucher was 1.5 years.[3]

Upon receipt, the household must find a suitable housing unit in the private housing market that meets HUD's Housing Quality Standards and for which the owner is willing to accept a voucher as payment. The location of the unit depends on the PHA's jurisdiction and the amount of funding the PHA has for portable voucher usage (i.e., allowing a voucher to be used outside of the PHA's jurisdiction). However, portability does not seem to be a major concern because the literature on the mobility of voucher recipients suggests that only short-distance moves relative to the recipient's original neighborhood are made—most likely to an adjoining neighborhood rather than to a county outside of the PHA's jurisdiction (Varady and Walker, 2003; Eriksen and Ross, 2013). PHAs must provide the household with a minimum of 60 days to perform the housing search. No maximum is specified, but extensions are granted at the discretion of the PHA. The typical maximum search time is 120 days. If all requirements are met, the subsidy is calculated as the difference between the unit's fair market rent (FMR) and 30% of the household's income I_{hh}:

$$subsidy = FMR - 0.3I_{hh}$$

It is possible for a recipient to supplement the subsidy and rent a unit that exceeds its FMR

[3]https://nlihc.org/resource/housing-spotlight-volume-6-issue-1

so long as the amount spent on housing does not exceed 40% of the household income.

In regards to overcrowding, an evaluation of a random assignment of housing vouchers in 6 different metropolitan areas was conducted by a third party, Abt Associates Inc., in 2006 to assess the effect of vouchers on material hardship and employment (Mills et al., 2006). Estimates of the intent-to-treat and treatment-on-treated effects, paired with in-depth interviews, suggest that voucher recipients move out of crowded living situations because the voucher helps them afford a nicer living arrangement, but the scope of the experiment is limited to individuals in very large metropolitan areas who would eventually receive a voucher regardless of participation in the experiment. Similarly, Currie and Yelowitz (2000) focus on recipients of public housing, concluding that public housing reduces the likelihood that a household overcrowds into a housing unit. Their results do not speak to the impact of vouchers on overcrowding per se, but their findings do contribute to the body of evidence suggesting that housing subsidies can address overcrowding.

The analysis presented in this paper examines the housing market as a whole rather than only recipient households. Interviewees in Mills et al. (2006) often state that the reason for overcrowding is financial difficulties. While vouchers can certainly address overcrowding among recipients by addressing financial difficulties, varying price movements in the broader rental market, as shown in Eriksen and Ross (2015), motivate a broader examination because it is unclear how a non-recipient reacts to an expansion in voucher supply. Specifically, Eriksen and Ross (2015) show that a home charging a rent near its fair market rent before the expansion in voucher supply on average experiences an increase in rental price after the expansion. A renter that does not receive a voucher might now run into financial difficulties affording rent. The resultant financial difficulty from an increase in voucher supply could lead to more overcrowding for both renters and homeowners because the troubled renter could choose to double-up with another household, irrespective of tenure, to cope with the financial hardship.

For illustration, suppose a home is overcrowded because 2 families live there. If only one family lived in the home, then it would not be overcrowded. Family B has financial difficulties in affording a home, so Family B must double-up with Family A. In this scenario, Family A can presumably afford the home without assistance. If Family B receives a voucher and relocates, then the voucher nets a new household that is not overcrowded because Family B can now afford a proper living space, while Family A remains in the original home. However, if Family A and Family B are doubled-up because both families have financial difficulties, making it hard for either family to afford the home separately, then Family A must find alternative accommodations when Family B moves upon receipt of a voucher. Possible alternatives for Family A include downsizing in the hopes of avoiding overcrowded living conditions, or finding another family willing to overcrowd in the home with Family A.

The Government Accountability Office (GAO) published a report in 2006 on rental housing assistance, crediting two programs, the Welfare-to-Work Vouchers and Fair Share Allocation Incremental Voucher programs, with significantly increasing the supply of housing vouchers between 2000 and 2002.[4] Together, the two programs constitute a plausibly exogenous increase in the supply of housing vouchers during this time period. The following subsections describe the two programs.

2.2.3 Welfare-to-Work Vouchers

Welfare-to-Work (WtW) consists of grant provisions as part of the Social Security Act. Welfare was an entitlement before WtW, but there was a large shift in the 1990s that focused on moving individuals out of welfare and into self-sufficiency. The WtW program was one of the programs designed to facilitate that shift. HUD secured funding in 1999 to meet WtW goals by providing about 50,000 additional vouchers worth $248.2 million in 1999 dollars. WtW vouchers were distributed the following year.

[4]https://www.gao.gov/products/gao-06-405

These WtW vouchers operated in a similar fashion to normal HCV vouchers. The only caveat was that those who were eligible, currently receiving, or had received within the last 2 years Temporary Assistance for Needy Families (TANF) aid were prioritized in receiving these vouchers. Otherwise, the distribution of vouchers followed the waitlist system described earlier. No other special services were offered to recipients outside of what was already locally accessible (Mills et al., 2006).

WtW Vouchers were allocated to PHAs on a competitive basis: a notice of funding availability published on January 28, 1999 in the Federal Register set guidelines for applications sent from the PHAs to the Grant Management Center (GMC). Applications were scored and ranked. Those earning at least 55 points out of 100 were eligible to be funded. Housing needs, based on the 1990 Census, in each PHA's jurisdiction accounted for only 20 points.[5] The remaining points were allocated to performance measures such as soundness of approach, relevant organizational experience, ability to leverage resources, and comprehensiveness of the proposed plan.

2.2.4 Fair Share Allocation of Incremental Vouchers

Before 2003, funding for the HCV program occurred through yearly appropriations that HUD would then distribute to each PHA in a competitive manner similar to the WtW program. This process was termed the Fair Share Allocation of Incremental Vouchers (FSV). A notice of funding availability is published in the Federal Register each fiscal year calling for applications from PHAs. In total, the number of FSV vouchers increased by approximately 157,000 vouchers between 2000 and 2002, for a total of $903.4 million in additional funding.[6]

[5]Housing needs were poorly defined in the application requirements because no specific measure constituted housing needs in this application.

[6]Notices of funding availability are published in the Federal Register on March 10, 2000; December 13, 2000; and February 22, 2002. Funding allocations for fiscal year 2000 was made available in the Federal Register on 4/18/2001. The allocations for fiscal year 2001 and 2002 are available on the Grant Management Center archives.

The criteria for competitive allocation are similar to those used in the WtW application process, but there was a heavier weight placed on housing needs. Unlike the WtW program, the FSV criteria defined housing needs as the number of very low-income renter households with a severe rent burden: households earning less than 50% of the AMI and allocating 50% or more of their gross income to rent. Regardless, a majority of the points in each application were awarded to performance measures rather than housing needs.

For both programs, plausible exogeneity results from the little weight placed on housing need when determining voucher allocations. The arbitrariness of allocations is supported by an admission of allocation mistakes, reported in the Federal Register on December 13, 2000. In essence, there remained some semblance of arbitrary judgment, even though the allocation process seemed systematic.

Despite housing needs accounting for very little in the criteria that determined voucher allocations, vouchers were quite possibly allocated in accordance with beliefs about the housing market based on contemporary concerns. For example, Los Angeles passed the Adaptive Reuse Ordinance in 1999, the first of its kind across the nation (Walk-Morris, 2021). This ordinance aimed to convert old, vacant buildings into living spaces. Such a goal could emphasize Los Angeles' housing needs above other metropolitan areas, leading to the allocation of more vouchers to Los Angeles based on beliefs about its housing needs. Beliefs are not directly observable, but if the allocations were made in such a manner, then changes in the supply of vouchers should exhibit some correlation with observable MSA characteristics that shape beliefs about housing needs.

Hence, the regressions in Table 2.1 seek to determine if a notable relationship between observable MSA characteristics and the change in voucher supply, as a result of the two programs, exists. Because Eriksen and Ross (2015) estimate voucher supply using MSA geographies from the American Housing Survey, which relies on 1980 geographies, some MSAs were combined to match the geographies in the 2000 Census to ensure that MSA geographies are

Table 2.1: Change in voucher supply is uncorrelated with observables.

Variables	(1) % change in voucher supply	(2)
Log Population	-200.37	-309.11
	(207.76)	(320.25)
Log Median HH Income	1,760.25	1,765.64
	(2,114.20)	(2,318.22)
Log per Capita Income	-2,971.81	-3,347.80
	(3,167.74)	(3,593.45)
% Vacant Housing	-124.32	-129.96
	(123.98)	(130.31)
% Rental Housing	-38.19	-39.38
	(40.68)	(43.70)
% Receiving Supplemental Income	236.62	226.84
	(241.11)	(237.04)
Housing Costs as % of Income	2,483.34	2,755.59
	(2,415.22)	(2,736.59)
% Below Poverty	83.29	97.95
	(93.20)	(108.08)
Northeast Region	-2.42	-127.29
	(157.42)	(222.69)
West Region	271.40	389.47
	(392.50)	(563.65)
South Region	190.71	229.41
	(268.81)	(336.55)
Constant	4,382.61	7,944.72
	(10,084.87)	(13,757.94)
Observations	106	91
R-squared	0.11	0.12
F-statistic	0.104	0.104

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Notes: All variables are at the MSA level. The dependent variable is the percent change in voucher supply between 1999 and 2003. Independent variables capture MSA characteristics from the 2000 Census. Because MSA geographies used to determine voucher supply slightly differ from geographies used to determine MSA characteristics in the 2000 Census, voucher supply is aggregated to match MSA geographies in the 2000 Census. Percent changes are calculated based on the new geographies. Column 1 shows that changes in voucher supply are not correlated with observable measures for housing need in 2000. Similarly, Column 2 focuses on MSAs with no geographical changes, and the lack of correlation remains.

consistent between the measure of voucher supply and MSA characteristics.[7] The dependent variable is the percent change in voucher supply between 1999 and 2003, rather than level changes in supply, to account for differences in the initial supply. If beliefs heavily influenced the allocation of vouchers, then observables that proxy for beliefs of housing needs should exhibit a strong connection to the percent change in voucher supply.

As Table 2.1 shows, concerns that allocations were made in accordance with unobservable beliefs or contemporary MSA characteristics are not evidenced in the data. First, Column 1 examines all MSAs, accounting for changes in geography, and the regression shows that no MSA characteristic has a statistically significant effect on percent change in voucher supply. To avoid potential aggregation bias when combining MSAs, Column 2 focuses only on MSAs with geographies that did not change. Again, no MSA characteristic is statistically significant, providing circumstantial evidence supporting the notion that the two programs constitute a plausibly exogenous increase in the supply of housing vouchers. Nonetheless, to further allay concerns over identification in the subsequent analysis, MSA by year fixed effects are included in the regressions.

Similarly, it does not seem that the initial supply of housing vouchers influenced the number of additional vouchers awarded to MSAs. Fig. 2.1 plots each MSA's percent increase in supply after receiving additional vouchers between 2000 and 2002 against its initial number of housing vouchers. A lack of statistical significance in the simple regression shown in the figure is evidence for a lack of association between the initial supply of housing vouchers and the number of additional vouchers granted by the WtW and FSV programs. Fig. 2.1 also plots the 95% confidence interval around the fitted values.

[7] MSAs were combined by matching constituent counties.

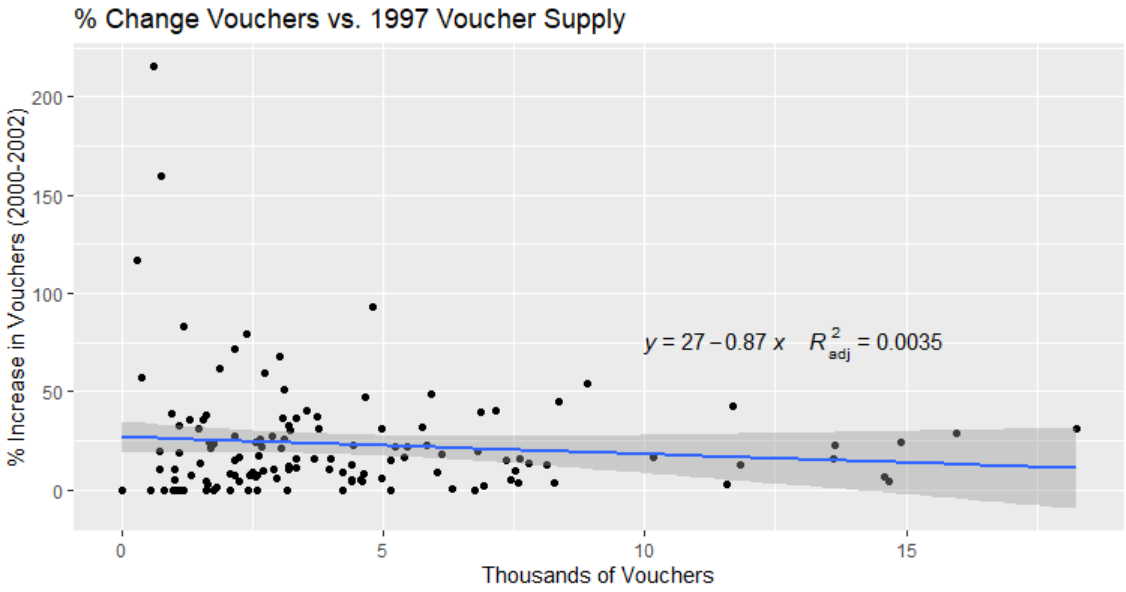

Figure 2.1: A simple regression of the percent change in voucher supply versus the initial supply of vouchers. Outliers in both the percent increase in vouchers and the initial supply of vouchers were excluded, leaving 130 MSAs in 1997 out of 135 in the panel. The coefficient is insignificant, both when including and excluding outliers, implying that the number of additional vouchers granted is not associated with the initial supply of vouchers.

2.3 Data and Empirical Strategy

Let i index the housing units, m the MSAs, and t the odd-numbered biennial American Housing Survey (AHS) years between and including 1997 and 2003. A linear probability model estimates the effect of changes in voucher supply on the likelihood a housing unit is overcrowded:

$$O_{imt} = \alpha_i + \gamma_t + \beta V_{mt} + \theta X_{imt} + \epsilon_{imt}\,, \tag{2.1}$$

where O_{imt} is a dummy that takes the value of 1 if housing unit i is overcrowded according to one of the three definitions (PPR, PPB, SQFTPP), V_{mt} is the logged supply of vouchers in MSA m in year t, X_{imt} is a vector of time-varying household characteristics that influence

overcrowding, α_i is a dwelling-specific fixed effect, and γ_t is the time fixed effect. Even though housing vouchers can only be used for rental housing, O_{imt} will reflect overcrowded households irrespective of tenure choice to best capture the possible experiences in the broader housing market, as highlighted by the in-depth interviews conducted by Mills et al. (2006). Interviewees often describe the necessity to move in with friends or relatives. In other words, those whose housing conditions are less certain are forced to double-up with those whose housing conditions are more stable, which can include homeowners. Given that α_i and γ_t control for unobserved time-invariant dwelling characteristics and common shocks, the effect is identified by variation in response to changes in voucher supply within each MSA over time. To further allay any concerns with endogeneity, MSA by year fixed effects are included with little impact on the main results. Standard errors are clustered at the MSA level to allow for dependence among housing units within the same housing market.

Before the estimation results are presented, the following subsections describe how Eriksen and Ross (2015) construct the supply of housing vouchers and how this paper uses the AHS to measure overcrowding and other controls.

2.3.1 American Housing Survey

Two sources of data are vital to this paper: the supply of housing vouchers between 1997 and 2003, made available by Eriksen and Ross (2015), and data on housing characteristics for the same time period, provided by the AHS national sample. The two sources of data work well together because they both cover the same 135 MSAs in the odd years between 1997 and 2003. For the analysis, the unit of observation is the housing unit within each MSA over the survey period.

The AHS national sample is a panel of housing units across the entire nation. There are several benefits to using these data: one, as just stated, is the ability to identify housing units

in the 135 MSAs in which the supply of housing vouchers changed in response to the Welfare-to-Work and Fair Share Voucher programs. Second, the AHS is a comprehensive survey that captures a wide variety of housing characteristics. Thus, individual households can be clearly identified as overcrowded, making quality of life for the individual household directly observable. By contrast, Sinai and Waldfogel (2005) look at rooms per capita measured at the more-aggregated census place level. Currie and Yelowitz (2000) define overcrowding as living in a unit with fewer than 3 living rooms or bedrooms, justified by focusing on families with 2 children, a restriction that is not imposed in this study. Third, household characteristics are tied to the housing unit, which allows the analysis to control for important determinants of overcrowding such as ethnic composition of the household, number of children, and presence of non-family members.

Since, the AHS national sample is designed to reflect housing across the entire nation, using it to construct measures at a finer geographic level than the nation will not lead to reliable estimates. Nevertheless, the AHS national sample is a panel of housing units that enables the regression analysis to control for unobserved time-invariant characteristics, either at the MSA or housing unit level, that could influence the allocation of vouchers. For example, the quality of public housing services offered by the PHAs in each MSA plays a role in allocating vouchers. Very little change in the quality of services, such as aid provided for finding a suitable home to rent, can be expected over the short time horizon of 6 years, so that a panel regression with fixed effects adequately controls for this variation.[8] Similarly, certain floorplans could make a housing unit more conducive to overcrowding, but the influence of this factor is absorbed in a panel setting.

[8]Mills et al. (2006) describes housing services provided by public housing agencies in 6 large metropolitan areas during an evaluation of the WtW program. Services were minimal, such as simply providing a listing of current properties willing to accept vouchers as payment. In more extreme cases wherein the housing search period is about to expire, some additional aid is provided, but more specialized services typically depleted funding too quickly to be made consistently available to the general population of voucher recipients over a long time horizon.

2.3.2 Supply of Housing Vouchers

The initial supply of vouchers is estimated using HUD's 1997 Picture of Subsidized Households under the assumption that there were no significant changes in the supply of housing vouchers between 1997 and 1999. The assumption is corroborated by the lack of notices of funding availability between 1997 and 1999. Funding received by HUD during this time period was most likely to renew existing housing vouchers, pay administrative costs, or expand the program by other means. Even though additional vouchers were not granted until after 2000, the pre-treatment period must include 1997 because the Picture of Subsidized Households is not available for 1999.

To estimate the change in the number of vouchers, Eriksen and Ross (2015) collected raw data from Federal Register publications, where HUD is required by law to publish its allocation decisions. Allocations from WtW occurred in 2000, whereas FSV allocations occurred throughout 2000–2002. The publications describe the number of vouchers awarded to particular PHAs. Because AHS MSA codes correspond to 1983 MSA geographic boundaries, the total amount awarded to an MSA is the total number of vouchers allocated to PHAs within its 1983 boundary. There were no other significant voucher allocations made in addition to the WtW and FSV programs between 2000 and 2003, as evidenced by a report by GAO in 2006, and by a lack of other notices of funding availability between 2000 and 2003.

2.3.3 Housing Characteristics

Characteristics for each housing unit are derived from the AHS national sample, which tracks a panel of housing units throughout the nation. The AHS is the most comprehensive national housing survey, providing current information on the size, composition, quality, and cost of housing. Even though each unit is described in the public-use sample, the finest level

of reported geography is the MSA. For confidentiality reasons, housing units belonging to areas with populations that are too small (fewer than 100,000 people) or belonging in a non-metropolitan area are not assigned MSA codes. Overcrowding is expected to occur primarily in metropolitan areas. Hence, this paper focuses on the effect of vouchers on overcrowding in metropolitan housing so that dropping observations from areas with small populations is not an issue.

The AHS uses a sample selected in 1985, so there are no concerns over sample selection during the study period. This sample of housing units was not updated or modified in any significant manner until 30 years later in 2015. Having the sample chosen in 1985 avoids any concerns over sample selection since a housing unit in the sample could not have been chosen based on whether it is overcrowded during the study period. The only changes made to the sample on a yearly basis are additions to the sample to account for new construction. For units that are unoccupied at the time of survey, the AHS collects information from landlords, rental agents, or neighbors.

A housing unit is deemed overcrowded if it houses greater than 1 PPR, greater than 2 PPB, or provides less than 165 SQFTPP. Additional information collected by the AHS determines whether the housing unit is rented, the median age in the household, the ethnic origins of individual household members, and the family structure. These characteristics are important because housing choice, and therefore living arrangement, is highly dependent on individual household characteristics.

2.3.4 Summary Statistics

Table 2.2 reports summary statistics for various housing characteristics in the AHS. Each year represents a cross-section of the data. All statistics are calculated by omitting any missing observations for that variable. It seems the AHS captures mainly homeowners with

Table 2.2: Summary statistics for the AHS national sample.

	1997	1999	2001	2003
# Observations	26,143	33,048	26,795	33,699
% Overcrowded (PPR)	3.670	3.880	3.550	3.735
% Overcrowded (PPB)	4.619	4.830	4.360	4.907
% Overcrowded (SQFTPP)	2.407	3.768	3.848	3.984
% Renting	40.730	39.938	39.500	38.585
Mean # Children	0.692	0.694	0.688	0.685
% Family Housing	73.503	73.003	72.599	72.872
% Eligible for Voucher	30.569	30.860	30.486	32.074
Mean Voucher Supply	5,568.630	5,568.630	6,104.037	6,580.185
Mean Change in Voucher Supply	0	0	535.407	476.148

Notes: Summary statistics are calculated for each survey year using a cross-section of the data. Each statistic omits any missing observations of the corresponding variable. It seems that the AHS mainly captures homeowners with families, low rates of overcrowding, and few children.

families, low rates of overcrowding, and few children. Many characteristics do not exhibit drastic changes over the years. In contrast, the number of existing vouchers on average increases dramatically by a few hundred between 1999 and 2001, relative to no changes between 1997 and 1999, and again between 2001 and 2003. This dramatic change in light of less noticeable shifts in characteristics between 1999 and 2001 hints at a causal interpretation between a change in voucher supply and a change in overcrowding. However, it is unclear if an increase in vouchers reduced overcrowding—the ambiguity in the summary statistics is in accordance with the story outlined in Section 2.2.

It is possible that a response to changes in voucher supply is not noticeable in the aggregate. Fig. 2.2 plots the percentage of overcrowded homes over time, grouping MSAs together by the quartile of percentage change in voucher supply. For example, the first quartile represents the percentage of overcrowded homes in MSAs between 1997 and 2003 that experience the smallest expansion in voucher supply (the bottom 25% of percentage change in vouchers). The order of the quartiles in the graph suggests that voucher allocations were not directly determined by overcrowding, for if it were, then MSAs with a large percentage of overcrowded

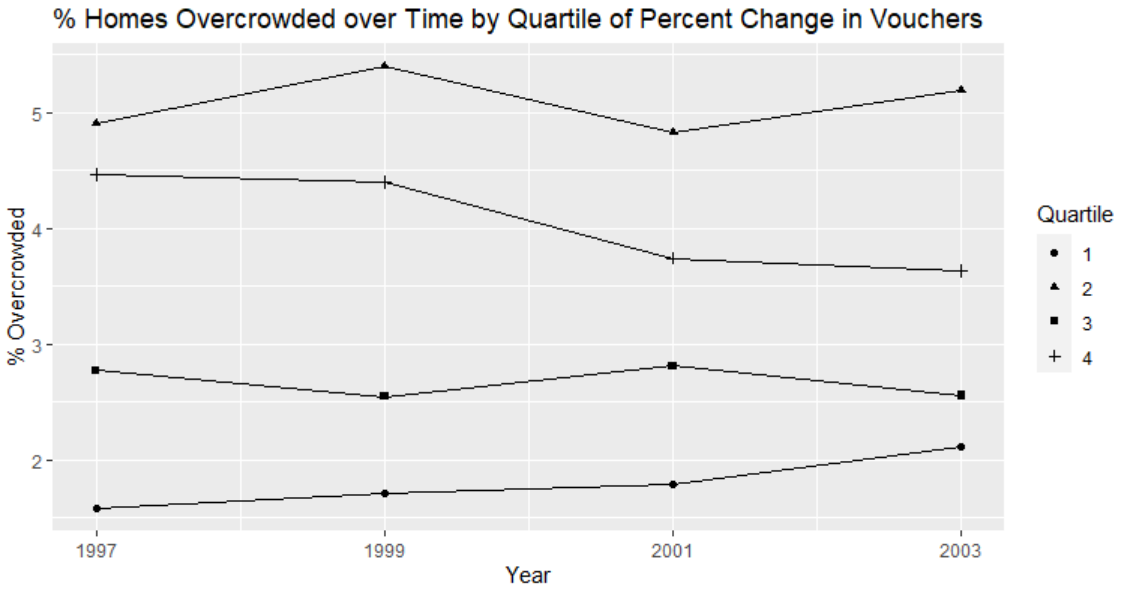

Figure 2.2: The percentage of overcrowded homes in the sample for each survey year stratified by the quartile of percentage change in voucher supply. This figure highlights the difference in response between homes located in MSAs experiencing relatively small changes in housing voucher supply (first quartile) versus that of homes located in MSAs experiencing relatively large changes in housing voucher supply (fourth quartile). The order of the quartiles in the graph also reflects how voucher allocations is likely not directly determined by overcrowding or other measures of distressed housing.

homes should have experienced the largest change in voucher supply. Thus, it is possible that other measures of distressed housing also did not heavily influence the allocation of vouchers. The most notable distinction in Fig. 2.2 is the difference in response between the first and fourth quartiles. Voucher allocations were made starting year 2000. The rate of overcrowding for the sample of MSAs experiencing little to no change in voucher supply (first quartile) increases between 2001 and 2003, whereas that of MSAs experiencing a relatively large change in voucher supply (fourth quartile) decreases between 2001 and 2003. These differences are later formally tested in stratified regressions.

2.4 Results

The analysis begins with examining cross-sectional data, akin to the study performed by Sinai and Waldfogel (2005). Testing for effects in a repeated cross-section serves as a first-pass analysis because it assumes that the housing market in each survey year is in equilibrium. The results could highlight if general patterns in overcrowding arise in the housing market due to changes in voucher supply. Indeed, Column 1 in Table 2.3 reflects a reduction in the likelihood that a housing unit is overcrowded based on people per room when more vouchers are available. This result does not seem to hold for the other definitions. Despite only one definition of overcrowding showing a response to changes in voucher supply, the controls in every column exhibit statistical significance and are correctly signed in accordance with prior literature.

One major concern is the possibility of unobserved unit characteristics that contribute to the likelihood that a unit is overcrowded. For example, the unit's floorplan, while small, might have a closet large enough for someone to use as a sleeping area, but this is not observed in the data. Likewise, even if square footage is limited, the layout of the unit could provide a room wide enough to include a reasonable room divider. To address this concern, the data is limited to only units that appear at least once in the pre-expansion period (1997–1999) and at least once in the post-expansion period (2001–2003), much in the same way as the panel analysis conducted on the AHS by Eriksen and Ross (2015). Unit fixed effects will now account for unobserved characteristics because of the data's panel structure.

Table 2.4 lists the results from using panel data. Changes in the estimated coefficients are so slight that rounding masks any differences relative to the estimates in the repeated cross-section, but statistical significance improves substantially for the coefficient on logged voucher supply. As with the repeated cross-section, the controls exhibiting statistical significance are signed in accordance with what is expected from the literature on overcrowding. Only

Table 2.3: Analysis of a repeated cross-section of housing units.

VARIABLES	(1) PPR	(2) PPB	(3) SQFTPP
Log Vouchers	-0.0081**	-0.0006	-0.0003
	(0.0035)	(0.0030)	(0.0026)
Rental	-0.0029	-0.0053	-0.0101**
	(0.0047)	(0.0045)	(0.0047)
Non-White HH	-0.0011	0.0032	0.0014
	(0.0026)	(0.0038)	(0.0043)
Hispanic HH	0.0227***	0.0382***	0.0189***
	(0.0065)	(0.0057)	(0.0043)
Multigenerational HH	0.0641***	0.0717***	0.0426*
	(0.0186)	(0.0271)	(0.0255)
# of Children	0.0937***	0.1027***	0.0485***
	(0.0083)	(0.0103)	(0.0059)
Children of Mixed Gender	-0.0588***	-0.0711***	-0.0334***
	(0.0077)	(0.0075)	(0.0079)
Eligible for Voucher	-0.0083***	-0.0043*	-0.0043
	(0.0027)	(0.0023)	(0.0029)
Under Poverty Line	0.0115***	0.0075**	0.0103***
	(0.0033)	(0.0037)	(0.0037)
Constant	0.0572*	-0.0079	0.0125
	(0.0336)	(0.0302)	(0.0238)
Observations	85,373	85,373	62,722
Adjusted R-squared	0.4897	0.5217	0.6916
Unit FE	YES	YES	YES
Year FE	YES	YES	YES
Clusters	135	135	135

Standard Errors clustered by MSA in Parenthesis
*** p<0.01, ** p<0.05, * p<0.10

Notes: All variables are at the unit level, except for the log of voucher supply. Independent variables capture housing unit characteristics. The dependent variable is always a dummy for whether the housing unit is overcrowded. Each column reflects a different condition for when the dummy takes a value of 1: greater than 1 persons per room (PPR), greater than 2 people per bedroom (PPB), and less than 165 square feet per person (SQFTPP). All specifications include unit fixed effects, year fixed effects, and cluster standard errors by MSA.

Table 2.4: Analysis of a panel of housing units.

VARIABLES	(1) PPR	(2) PPB	(3) SQFTPP
Log Voucher Supply	-0.0081***	-0.0006	-0.0003
	(0.0028)	(0.0025)	(0.0020)
Rental	-0.0029	-0.0053	-0.0101***
	(0.0038)	(0.0037)	(0.0037)
Non-White HH	-0.0011	0.0032	0.0015
	(0.0021)	(0.0031)	(0.0034)
Hispanic HH	0.0227***	0.0383***	0.0189***
	(0.0053)	(0.0046)	(0.0034)
Multigenerational HH	0.0642***	0.0718***	0.0427**
	(0.0151)	(0.0221)	(0.0201)
# of Children	0.0939***	0.1029***	0.0486***
	(0.0067)	(0.0084)	(0.0046)
Children of Mixed Gender	-0.0591***	-0.0714***	-0.0334***
	(0.0062)	(0.0060)	(0.0062)
Eligible for Voucher	-0.0083***	-0.0043**	-0.0043*
	(0.0022)	(0.0018)	(0.0023)
Under Poverty Line	0.0114***	0.0073**	0.0103***
	(0.0027)	(0.0031)	(0.0029)
Constant	0.0575**	-0.0076	0.0126
	(0.0274)	(0.0247)	(0.0187)
Observations	84,782	84,782	62,208
# of Units	28,530	28,530	23,672
Adjusted R-squared	0.1254	0.1260	0.0567
Unit FE	YES	YES	YES
Year FE	YES	YES	YES
Clusters	135	135	135

Standard Errors clustered by MSA in Parenthesis
*** p<0.01, ** p<0.05, * p<0.10

Notes: All variables are at the unit level, except for the log of voucher supply. Independent variables capture housing unit characteristics. The dependent variable is always a dummy for whether the housing unit is overcrowded. Each column reflects a different condition for when the dummy takes a value of 1: greater than 1 persons per room (PPR), greater than 2 people per bedroom (PPB), and less than 165 square feet per person (SQFTPP). All specifications include unit fixed effects, year fixed effects, and cluster standard errors by MSA.

overcrowding defined by people per room in Column 1 seems to respond to changes in voucher supply. Although only one estimate is statistically significant, the coefficients in Columns 2 and 3 for voucher supply are correctly signed. The estimate in Column 1 has a straightforward interpretation: for a 10% increase in the supply of vouchers, any one housing unit experiences an average decrease of 0.081 percentage points in the probability of being overcrowded.

To place the estimate in context, the mean of the overcrowding dummy in the entire sample is 3.74%, so that about 3,168 out of 84,782 units in the sample are overcrowded. A decrease of 0.081 percentage points in the probability of being overcrowded should lead to the elimination of 69 overcrowded housing units. The average supply of vouchers over all MSAs and years is 5,955. Hence, about 595 vouchers (10% additional vouchers) leads to eliminating 69 overcrowded housing units, or about 12% of vouchers goes to households in overcrowded living situations.

The data thus far includes both unsubsidized housing units and subsidized units, which makes interpreting the effect ambiguous. It is unclear whether the effects are a result of changes in subsidized households' behaviors, or a result of that in unsubsidized households. Out of 118,729 total observations, only 1,824 definitively respond to whether the housing unit is subsidized by a voucher or not. Of those 1,824 housing units, only 900 units say the rent is subsidized by a voucher. Restricting the data to subsidized rental households does not yield a statistically significant effect. Nevertheless, omitting respondents that receive vouchers from the data yields a negative and statistically significant coefficient on the supply of vouchers, which supports the results in Table 2.4 and adds evidence to support the notion that adjustments occur in the broader housing market.

To further limit the influence of potential endogeneity, MSA by year fixed effects are included in the estimation in addition to the unit-specific fixed effects. Table 2.5 reports the results when including MSA by year fixed effects. All overcrowding measures now exhibit a negative

Table 2.5: Analysis of a panel of housing units using MSA by year FE.

VARIABLES	(1) PPR	(2) PPB	(3) SQFTPP
Log Vouchers	-0.0053***	-0.0041***	-0.0018***
	(0.0003)	(0.0003)	(0.0002)
Rental	-0.0022	-0.0048	-0.0100***
	(0.0037)	(0.0036)	(0.0038)
Non-White HH	-0.0017	0.0029	0.0021
	(0.0022)	(0.0032)	(0.0033)
Hispanic HH	0.0227***	0.0382***	0.0188***
	(0.0053)	(0.0046)	(0.0034)
Multigenerational HH	0.0646***	0.0722***	0.0435**
	(0.0151)	(0.0221)	(0.0200)
# of Children	0.0938***	0.1028***	0.0486***
	(0.0068)	(0.0084)	(0.0047)
Children of Mixed Gender	-0.0586***	-0.0708***	-0.0332***
	(0.0063)	(0.0060)	(0.0062)
Eligible for Voucher	-0.0085***	-0.0044**	-0.0043*
	(0.0024)	(0.0018)	(0.0023)
Under Poverty Line	0.0114***	0.0074**	0.0102***
	(0.0028)	(0.0031)	(0.0030)
Constant	0.0332***	0.0224***	0.0259***
	(0.0031)	(0.0030)	(0.0019)
Observations	84,782	84,782	62,208
Number of CONTROL	28,530	28,530	23,672
Adjusted R-squared	0.1254	0.1260	0.0567
Unit FE	YES	YES	YES
Year FE	YES	YES	YES
MSA by Year FE	YES	YES	YES
Clusters	135	135	135

Standard Errors clustered by MSA in Parenthesis
*** p<0.01, ** p<0.05, * p<0.10

Notes: All variables are at the unit level, except for the log of voucher supply. Independent variables capture housing unit characteristics. The dependent variable is always a dummy for whether the housing unit is overcrowded. Each column reflects a different condition for when the dummy takes a value of 1: greater than 1 persons per room (PPR), greater than 2 people per bedroom (PPB), and less than 165 square feet per person (SQFTPP). All specifications include unit fixed effects, year fixed effects, and now MSA by year fixed effects. Standard errors are still clustered by MSA.

and statistically significant response to changes in voucher supply. However, many of the MSA by year fixed effects were omitted due to issues with collinearity, so these new estimates may reflect endogeneity in the MSA-year pairs that could not be included in the regressions. Nevertheless, the estimated effect when overcrowding is defined using people per room does not dramatically change in sign or magnitude, which lends additional credibility to the original panel estimate that does not include MSA by year fixed effects. The specification that yields those results (the panel model without MSA by year fixed effects) is henceforth the preferred specification.

2.5 Mechanisms

The event study in Fig. 2.2 suggests differing effects for MSAs experiencing different magnitudes of change in voucher supply. To formalize this difference, housing units from the panel are grouped together based on the quartile of percentage change in voucher supply for their respective MSAs. All subsequent analysis focuses on overcrowding defined by people per room because results thus far are the most successful for this definition. Columns 1 through 4 of Table 2.6 simply regresses the dummy for whether a housing unit is overcrowded on the logged voucher supply, accounting only for unit fixed effects. The second and fourth quartiles (Columns 2 and 4) show a decrease in the likelihood that any one housing unit is overcrowded. However, the lack of statistical significance in Columns 5 through 8, where year fixed effects and controls are included in addition to unit fixed effects, suggests that the impact of vouchers is difficult to measure within individual quartiles.

Vouchers are meant to help low-income households, so to elaborate on the mechanisms behind the effect of vouchers on overcrowding, it might be prudent to stratify the data based on household income. To ensure that stratification is consistent, each housing unit is stratified by household income within its respective MSA across all years. Thus, when

Table 2.6: Analysis of stratification by % change in voucher supply.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Quartile	1	2	3	4	1	2	3	4
Log Vouchers	0.0569	-0.0324*	0.0015	-0.0092**	-0.0673	-0.0485	-0.0516	-0.0029
	(0.0614)	(0.0195)	(0.0109)	(0.0045)	(0.1111)	(0.0422)	(0.0427)	(0.0055)
Observations	12,995	32,563	23,978	15,246	12,995	32,563	23,978	15,246
Adjusted R-squared	0.3599	0.4560	0.3444	0.3965	0.4147	0.5284	0.4160	0.4958
Unit FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	NO	YES	YES	YES	YES
Controls	NO	NO	NO	NO	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Notes: All variables are at the unit level, except for the log of voucher supply. Independent variables (omitted from the table) capture housing unit characteristics. The dependent variable is always a dummy for whether the housing unit is overcrowded according to people per room. Each column collects observations according to its respective MSA's quartile of percentage change in voucher supply. Standard errors clustered by MSA are not feasible because of the limited number of MSAs per quartile.

focusing on units in the first quartile, for instance, only units with at least one observation in the pre-expansion period and at least one observation in the post-expansion period in the bottom 25% of its respective MSA's household income distribution across all years is included in the sample. Keeping only units that do not move into different income quartiles eliminates the possibility of estimating effects that are a result of dramatic income changes. Eriksen and Ross (2015) focused only on rental housing, which justifies a stratification of their data based on the rental unit's rent relative to the unit's fair market rent prior to voucher expansion. Since this study considers overcrowding in units that are both owned and rented, stratification in the same fashion might not be the best choice because imputed rent for homeowners is not always straightforward to estimate. In contrast, every household is able to report a household income.

Stratifying the data by household income leads to an interesting result: in Table 2.7, the households with the lowest incomes do not experience much of a change in the probability of overcrowding. Rather, the reduction in the probability of overcrowding strengthens moving up the income distribution, with the strongest reduction seen in the 4th quartile of income.

Table 2.7: Analysis of stratification by income and tenure.

VARIABLES	(1) 1st Quartile	(2) 2nd Quartile	(3) 3rd Quartile	(4) 4th Quartile	(5) Owned	(6) Rental
Log Vouchers	-0.0093	-0.0184***	-0.0195*	-0.0220***	-0.0115***	-0.0081
	(0.0064)	(0.0065)	(0.0115)	(0.0022)	(0.0019)	(0.0078)
Constant	0.0734	0.1577***	0.1665	0.1932***	0.0880***	0.0706
	(0.0577)	(0.0587)	(0.1060)	(0.0196)	(0.0176)	(0.0738)
Observations	12,103	9,622	9,873	13,001	47,520	30,076
Number of Units	4,469	3,927	3,953	4,568	15,307	10,228
Adjusted R-squared	0.2119	0.1996	0.0775	0.0261	0.0710	0.1805
Unit FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
Clusters	135	135	135	135	135	135

Standard Errors clustered by MSA in Parenthesis
*** p<0.01, ** p<0.05, * p<0.10

Notes: All variables are at the unit level, except for the log of voucher supply. Independent variables (omitted from the table) capture housing unit characteristics. Dummy for tenure is omitted from the set of independent variables when stratifying by tenure. The dependent variable is always a dummy for whether the housing unit is overcrowded according to people per room. Columns 1–4 collect observations based on the household's quartile of income. The effect strengthens in magnitude moving up the income distribution. Columns 5–6 collect observations based on the household's tenure status. A significant effect in Column 5, but not in Column 6, supports the anecdotes about overcrowding.

This outcome is consistent with anecdotes that point to how people experiencing misfortune must double-up with those who possess more stable housing, and by extension, who are more likely to be higher up on the income distribution. When vouchers become available, recipients move out and find their own housing, leaving the original, stable household no longer overcrowded. Further supporting this notion is a significant effect in Table 2.7 Column 5, which focuses on observations of owned housing units throughout the entire study period. In contrast, Column 6 finds no significant effect of vouchers on the likelihood of overcrowding when focusing on observations of rental housing units, although the point-estimate has the correct sign.

Given that households in the lowest part of the income distribution do not respond to increases in voucher supply, a natural follow-up to that result would be to ask whether households experiencing the most severe overcrowding receive the most benefits from vouchers.

This analysis stratifies the data by level of crowding in 1997 and 1999, then follows these units throughout time in the panel. Three categories from the US Census are specifically considered: units with $0.5 < PPR < 1$ (not overcrowded), $1 < PPR < 1.5$ (overcrowded), and $PPR > 1.5$ (severely overcrowded). No discernible effects are expected for the first category, in which homes start out with acceptable levels of crowing.

In Table 2.8, Column 1 confirms that units starting at an acceptable level of crowding do not react to changes in vouchers. The larger magnitude in Column 3 relative to Column 2 reflects the intuition that vouchers have a stronger impact on homes that are in most need because of the lack of statistical significance in Column 3, it seems that homes on the margin of the overcrowding threshold experience the most benefits from an increase in voucher supply. Columns 4 and 5 support this notion since there is no discernible decrease in level of crowding for homes that are initially severely overcrowded. A discernible decrease in level of crowding for homes that are close to the overcrowding threshold suggests that it is the homes on the margin that benefit most.

The results from stratifying the data paint one story about how vouchers reduce overcrowding. From Table 2.7, the effect of vouchers grows stronger moving up the income distribution. However, housing vouchers are targeted at low-income households that, by definition, are not at the top of the income distribution. Since the data is stratified such that homes do not move out of its income quartile during the study period, it must be that voucher recipients were doubled-up with a more stable household possessing a higher income. Examining the level of crowding in Table 2.8 expands on this story by suggesting that households at the margin of being overcrowded, rather than households that are severely overcrowded, benefit the most from expanding the voucher supply. Altogether, the main results from Table 2.4 say that vouchers are effective at reducing overcrowding in the general housing market despite the concerns raised over increases in rent for a particular segment of the rental housing market.

Table 2.8: Analysis of effects on level of crowding.

VARIABLES	(1) Not Overcrowded	(2) Overcrowded	(3) Severely Overcrowded	(4) $1 < PPR < 1.5$	(5) $PPR > 1.5$
Log Vouchers	0.0082	-0.0820***	-0.1603	-0.0326**	0.0858
	(0.0056)	(0.0224)	(0.2369)	(0.0159)	(0.4621)
Constant	-0.1406***	0.8658***	1.9115	0.8731***	0.0494
	(0.0499)	(0.2129)	(2.3859)	(0.1552)	(4.6240)
Observations	24,805	3,069	957	3,069	957
# of Units	7,609	948	304	948	304
Adjusted R-squared	0.1120	0.4277	0.5167	0.5253	0.5409
Controls	YES	YES	YES	YES	YES
Unit FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Clusters	135	104	49	104	49

Standard Errors clustered by MSA in Parenthesis
*** p<0.01, ** p<0.05, * p<0.10

Notes: All variables are at the unit level, except for the log of voucher supply. Independent variables (omitted from the table) capture housing unit characteristics. The dependent variable in Columns 1–3 is a dummy for whether the housing unit is overcrowded according to people per room. Columns 1–3 subset the data based on the housing unit's initial (pre-expansion) level of crowding. The first column considers units with $0.5 < PPR < 1$, the second with $1 < PPR < 1.5$, and the third with $PPR > 1.5$. It seems that vouchers benefit only units on the margin of overcrowding. Columns 4 and 5 consider the level of crowding itself. Clustered standard errors based on 49 clusters in Columns 3 and 4 might seem erroneous, but switching to robust standard errors does not change the results.

2.5.1 Relating to Prior Literature

The story that voucher recipients were doubled-up with a more established household is similar to the market mechanism described in Sinai and Waldfogel (2005). They illustrate their story by taking into consideration a family that cannot afford housing services without assistance. If this family is given a housing voucher, then the subsidy generates new demand for housing in the market because that family would not have purchased housing services otherwise. A new family household is created and the housing subsidy does not crowd-out housing construction. In contrast, suppose a voucher goes to a household that could afford housing services without assistance. The subsidy does not generate new demand, so a new family household is not formed and there is no new construction. That is, crowd-out is complete.

Sinai and Waldfogel (2005) find that housing subsidies lead to incomplete crowd-out of private housing construction. Thus, based on their posited mechanism, new family housing should be observable. The AHS lends itself to test this outcome because family relations are observed in the housing unit. Similar to analyzing overcrowded homes, the analysis begins with an attempt to replicate their results by showing that in a repeated cross-section, a housing unit is more likely to house a family when the supply of housing vouchers increases. Subsequently, to account for possible endogeneity, the analysis is narrowed to a panel of housing units. Sinai and Waldfogel (2005) also claim that effects are stronger in more elastic markets wherein the shift in housing supply is not muted by shifts in prices. This claim can be tested as well using a measure for housing supply provided by Saiz (2010) for select MSAs in the sample.

As seen in Table 2.9, there is limited evidence in the AHS data to support the posited mechanism in Sinai and Waldfogel (2005). The first column represents estimates from the repeated cross-section. While the estimated coefficient is correctly signed, the estimate is not statistically significant. Column 2 further refines the data to reflect a panel of housing units, but this refinement does not provide more conclusive results. Column 3 includes MSA by year fixed effects and yields a significant result with the correct sign. However, as with the analysis on overcrowding, the specification in Column 3 must omit a number of MSA by year fixed effects because of collinearity. This specification is not the preferred specification in this paper, so the result must be viewed with some caution. Further limiting the sample to MSAs above and below the median housing supply elasticity (estimated by Saiz (2010)) in Columns 4 and 5, respectively, yields equally inconclusive results.

Table 2.9: Analysis of family housing in the AHS.

VARIABLES	(1) Cross-Section	(2) Panel	(3) Panel	(4) Elastic Supply	(5) Inelastic Supply
Log Vouchers	0.0063	0.0064	0.0137***	-0.0112	0.0124
	(0.0065)	(0.0052)	(0.0003)	(0.0309)	(0.0295)
Constant	0.5106***	0.5093***	0.4197***	0.6268**	0.4520
	(0.0596)	(0.0478)	(0.0043)	(0.2557)	(0.2811)
Observations	85,373	84,782	84,782	17,686	59,818
Adjusted R-squared	0.6385	0.0682	0.0711	0.0902	0.0646
Unit FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
MSA by Year FE	NO	NO	YES	NO	NO
Clusters	135	135	135	48	48

Standard Errors clustered by MSA in Parenthesis
*** p<0.01, ** p<0.05, * p<0.10

Notes: All variables are at the unit level, except for the log of voucher supply. The dependent variable is a binary indicator for whether the housing unit houses only family members or if it houses non-family members. Limited evidence is provided in support of Sinai and Waldfogel (2005) because Column 3, which includes MSA by year fixed effects, is not the preferred specification in this paper.

2.5.2 Hazard Model

The mechanism in Sinai and Waldfogel (2005) might still hold despite not finding any evidence for it in family housing. Namely, additional vouchers might be allocated to people who require aid to consume housing services. This could occur in several ways: either the person was homeless before receipt of a housing voucher, doubled-up in an overcrowded living situation, or facing other tenuous circumstances leading to housing insecurity. After all, the results from stratifying housing units by income suggest that vouchers deal with overcrowding by reducing the number of cases wherein the recipient had to live with a more stable household. New demand for housing is created through additional vouchers, which should lead to some response in the housing stock. In other words, there should be a noticeable increase in new housing.

The unique structure of the AHS can speak to this possibility: new observations are added to the original sample of housing units to account for new housing. These new units are identifiable in the AHS and can be modeled using a Cox proportional hazard model after some modification. The addition of new housing can be thought of as the opposite of "death". The year a new housing unit is added to the AHS represents the unit's "birth", so that the event is left-censored—the birth of units before the 1997 AHS is unknown given the data. To fit a typical hazard model, which deals with right-censored data, without imposing strong distributional assumptions, time is reversed in the data so that the "birth" of new housing reflects its "death" because it drops out of the sample. Since a Cox proportional hazard model does not rely on a strict panel structure, all data in the AHS are used to estimate the hazard model. Only 346 units (1% of the total) have only a single observation in the data and are ignored in the analysis.

When going backwards in time, the supply of vouchers decreases. Hence, if more vouchers lead to the construction of new housing, then it should be that as the supply of vouchers decreases, the chances of a housing unit dropping out of the data also decreases. Because the movement of voucher supply coincides with the chances of a housing unit dropping out, the hazard model should report a positive coefficient. Equivalently, the resultant hazard ratio should be greater than 1 to reflect this pattern.

The hazard ratios reported in Table 2.10 yield some evidence for vouchers leading to new construction. In Column 1 of Table 2.10, the only independent variable is the log of voucher supply. The estimated hazard ratio would suggest that vouchers lead to a decrease in new construction, but that estimate is not entirely correct because housing markets are thought to vary in their responses across MSAs. Stated differently, each MSA represents its own housing market, which is thought to be independent of housing markets in other MSAs. Including MSA dummies in Column 2 for MSAs with observable new construction yields a hazard ratio above 1, as expected. Therefore, according to the hazard model, there is some

Table 2.10: Analysis of new housing using a hazard model.

VARIABLES	(1) New Housing	(2) New Housing
Log Vouchers	0.7730***	1.1817*
	(0.0446)	(0.1180)
Observations	85,986	85,986
MSA FE	NO	YES
Clusters	135	135
# Subjects	33353	33353
# Failures	551	551

Standard Errors clustered by MSA in Parenthesis
Hazard ratios in lieu of model coefficients are reported above.
*** p<0.01, ** p<0.05, * p<0.10

Notes: Observations are individual housing units in each survey year between 1997 and 2003. The dependent variable captures whether the housing unit is newly constructed in a specific year, after which the observation drops out of the sample. The independent variable is the logged supply of vouchers at the MSA-level, corresponding to the unit's MSA. After accounting for the idiosyncrasies of each housing market by adding MSA fixed effects, additional housing vouchers is associated with more construction of new housing.

evidence in support of the story told in Sinai and Waldfogel (2005). That is, MSAs that receive more vouchers are more likely to have new construction.

2.6 Conclusion

In this paper, a plausibly exogenous shock to the supply of housing vouchers was utilized to explore the effects of housing vouchers on overcrowding in the general housing market. The effect a priori is ambiguous: voucher recipients are provided with a housing subsidy to rent a suitable housing unit, but increases in price for certain parts of the rental housing market (Eriksen and Ross, 2015) could force some households to overcrowd in an attempt to compensate for higher housing costs. Overcrowding is linked to adverse health outcomes such as

stunted child development, stronger negative reactions to social hassles, and increased risk of spreading infectious diseases such as COVID-19 (Evans, 2006; Ferguson et al., 2013; Emeruwa et al., 2020). Despite the number of studies capturing the link between overcrowding and adverse outcomes, it is difficult to directly address overcrowding in a home.

A panel regression provides evidence for a reduction in overcrowding in response to an increase in the supply of housing vouchers. Increasing the voucher supply by 10% leads to an average decrease of 0.081 percentage points in the probability that a housing unit is overcrowded. In real terms, 595 additional vouchers lead to eliminating 69 overcrowded homes, or about 12% of additional vouchers goes to households in overcrowded living situations.

Stratifying the data by household income and tenure suggests that vouchers eliminate overcrowding by enabling recipients to move out of already established households. That is, recipients were likely doubled-up with stable, higher-income households because of misfortune or financial difficulties, problems that vouchers directly address. However, the solution to overcrowding is not as simple as expanding voucher supply as much as possible because the households suffering from severe overcrowding are not the ones receiving the most benefits from a greater availability of vouchers. The silver-lining is that expanding the supply of vouchers seems to spur new housing construction, reinforcing the story in Sinai and Waldfogel (2005). Hopefully with more readily available housing, households might be able to opt for less crowded living arrangements.

Further research on overcrowding should explore a causal link between overcrowding and health outcomes to address the dearth of causal interpretations in the current literature. Additionally, garnering more evidence to arrive at a consensus about the relevant threshold above which crowding becomes overcrowding is important to unify previous and future work on overcrowding. Perhaps more effective policies to address overcrowding will result from such findings. This paper certainly suggests that federal programs such as the Section 8 Housing Choice Voucher program could be a solution, but the most effective programs would

be at the local level to best address the nuances of housing markets in each MSA.

Chapter 3

Grocery Stores Raise Property Values: Evidence from FRESH

3.1 Introduction

The Whole Foods Effect colloquially refers to the positive correlation between house values and the number of nearby upscale grocery stores, such as its namesake, Whole Foods. Despite only being a correlation, the Whole Foods Effect is misconstrued to represent a causal effect: when a grocery store opens, surrounding property values rise. Claiming a causal relationship between property values and grocery stores is difficult because where people live and where grocery stores operate are endogenous choices. On one hand, a rise in property values could reflect general improvements to the neighborhood, attracting grocery stores to open nearby. On the other hand, a new grocery store could provide local amenities, attracting more residents, and raising property values.

This paper establishes that grocery stores are local amenities that increase residential property values by analyzing the effects of the Food Retail Expansion to Support Health (FRESH)

program in New York City (NYC). Introduced in 2009 and still ongoing, FRESH offers financial and zoning incentives for the opening or renovation of grocery stores in areas of high need. Expansion over time in the areas where incentives are offered allows measurement of the intent-to-treat effect of FRESH on property values (that is, the effect of an area's eligibility for incentives) over the 2005-2019 period. A difference-in-difference model using a repeated-cross section of property transactions based on this geographic change suggests that simply offering incentives to build or renovate a grocery store leads to an increase of 13.2% in the sales price of a residential property. To isolate the causal impact of the actual opening of a grocery store on property values, a different difference-in-difference regression based on store proximity focuses on properties surrounding 13 newly constructed stores that opened to the public because of FRESH at different points in time. Property transactions near these stores versus those farther away constitute the comparison. While these results are less precise than the intent-to-treat results, a property near a newly constructed store nevertheless experiences a 7.93% increase in its value when assessed values are used in place of sale prices.

An exploration of the mechanisms behind the effect suggest that grocery stores directly contribute to the increase in property values because they directly improve local amenities. Furthermore, grocery stores attract complementary retail and services, such as restaurants, thereby leading to a further increase in property values through an indirect improvement of local amenities. The indirect effect is evidenced by an observable increase in sales for restaurants near new FRESH stores relative to restaurants farther away, suggesting potential profits as an incentive for restaurants to locate close to a grocery store. Indeed, an observable increase in restaurant longevity supports the idea that restaurants have responded to this incentive to locate close to a grocery store.

Prior studies have not been able to conclude that grocery stores are a local amenity. A nearby grocery store could be appealing because it can provide more convenience in ob-

taining necessities.[1] In contrast, a grocery store could be unappealing because it can lead to undesirable traffic congestion by attracting non-residents to the neighborhood, requiring the disposal of trash, and receiving regular product deliveries.[2] Furthermore, the endogeneity between residential location choice and store location choice complicates disentangling the causal relationship between grocery stores and property values, a relationship that is necessary to conclude whether a grocery store is an amenity. This paper is the first to overcome the endogeneity issue and provide evidence indicating that grocery stores are an amenity. This finding speaks to several strands of literature, one of which is the literature on the hedonic pricing of amenities. Rosen (1974) provides a theoretic foundation for hedonic price analysis, resulting in a broad methodology with a wide variety of applications for pricing housing amenities such as open spaces (Blomquist and Worley, 1981), homeowner's associations (Clarke and Freedman, 2019), and school quality (Yinger, 2015).

A finding that grocery stores raise property values also relates to the literature on food deserts, which are low-income areas that have limited access to healthy, affordable foods. Bitler and Haider (2011) provide a good overview on food deserts from an economics perspective. They note that researchers have not been able to convincingly document the presence or absence of food deserts on a national scale, most likely due to shortcomings in data. In addition to showing a lack of convincing studies on the causes of food deserts, Bitler and Haider (2011) provide many examples of initiatives to eliminate food deserts, yet little research exists evaluating the effects of these initiatives. Allcott et al. (2019), using a nationwide event study, find that the opening of a grocery store does not significantly alter the nutritional quality of goods consumed by households. If these initiatives fail their primary goal of eliminating nutritional inequality, as suggested by Allcott et al. (2019), then at the very least, this paper shows that there are benefits to homeowners and the city in the form of increased property values.

[1] Allcott et al. (2019), Cummins et al. (2014), Hendrickson et al. (2006), Martin et al. (2014)

[2] Jiao et al. (2011), Teller et al. (2018), Rickard et al. (2013), Kennedy et al. (2016), Vildosola et al. (2020)

Lastly, the paper's findings also relate to the literature on gentrification. This is the first paper to document in a rigorous causal framework the Whole Foods Effect, a term that describes how property values rise in response to anticipated community change signaled by generally more upscale food retailers starting to market more sustainable, healthy products.[3] Its common understanding implies that grocery stores cause property values to rise despite a lack of conclusive evidence. Glaeser et al. (2018) document the association between cafes and house prices using Yelp data, finding that an additional Starbucks is associated with a 0.5% increase in a housing price index, but make no causal claim. Their study also finds a positive property-value correlation with grocery stores. This present paper evaluates the FRESH program to establish causal evidence in support of the Whole Foods Effect. Furthermore, the analysis accounts for unobserved factors that jointly determine property values and selection into the FRESH program, eliminating a possible source of bias in the estimate.

Section 3.2 discusses the context for FRESH, Section 3.3 describes the data and methods used in this paper, Section 3.4 presents the results, Section 3.5 explores the mechanisms behind the estimated effects, and Section 3.6 concludes.

3.2 Background

Grocery stores have a long history in NYC. An article on real estate by *The New York Times* depicts the small mom-and-pop grocery store as the linchpin of the local community.[4] Despite their perceived importance, the article cites a finding by Strategic Resource Group, a retail consultant, saying that family-owned grocers of less than 7,000 square feet are disappearing: between 2005 and 2015, there was a decline of 8% in the number of family-owned grocers.

[3]Discussion on the Whole Foods Effect in the media available at `https://medium.com/@daliakramirez/the-whole-foods-effect-foodie-culture-and-culinary-gentrification-acaf7ebbba49`

[4]`https://www.nytimes.com/2016/11/06/realestate/new-york-city-small-supermarkets-are-closing.html`

In real terms, there were about 300 store closures, two-thirds of which occurred in arguably less affluent areas outside of Manhattan. High rents and increased competition are blamed for the closures. In a similar discussion, *The Atlantic* highlights shifting trends in consumer spending, noting a general increase in expenditures on food away from home (i.e., eating out) using the Consumer Expenditure Survey, a survey conducted by the BLS.[5] Essentially, *The Atlantic* concludes that grocery stores are unsurprisingly going out of business because overall, people are spending less money at grocery stores. Even though 300 store closures over a decade might not seem dramatic for NYC as a whole, these stores are thought to be heavily interconnected with the local community. Hence, there has been a longstanding concern at the local level about a shortage of grocery stores.

The Food Retail Expansion to Support Health (FRESH) program was introduced in 2009 in NYC as a response to a 2008 study, *Going to Market*,[6] initiated by the Mayor's Office of NYC and conducted by the NYC Food Policy Coordinator, the NYC Economic Development Council (EDC), and the NYC Department of Health. Constituents raised concerns over a shortage of supermarkets due to neighborhood grocery store closures despite an increase in population. *Going to Market* finds that approximately 3 million New Yorkers lived in areas dubbed in high need of fresh food purveyors, based on neighborhood characteristics such as population, household income, and the prevalence of diet-related diseases.

The rhetoric in *Going to Market* heavily emphasizes supply-side constraints as the main reason for a lack of access to fresh produce. This issue is exacerbated by land-use constraints, which are identified as the limiting factor in the expansion of existing grocery stores or the creation of new ones. FRESH addresses these land-use constraints by providing two types of incentives to developers and current grocery store operators. Recipients of these incentives

[5] `https://www.theatlantic.com/business/archive/2016/11/millennials-groceries/506180/`

[6] A PDF of the report is available at `https://www1.nyc.gov/assets/planning/download/pdf/plans/supermarket/supermarket.pdf`
A PowerPoint presentation is available at `https://www1.nyc.gov/assets/planning/download/pdf/plans/supermarket/presentation_2008_10_29.pdf`

use them to either build or renovate retail space for the purpose of providing fresh groceries.

First of the two incentives is a financial incentive, similar to that already provided by the Empire Zones Program. This incentive is awarded on a discretionary basis. Examples of financial benefits include fixed building taxes for the next 25 years, land tax abatement for the next 25 years, and waived sales tax on materials used for the construction or renovation of the grocery store. The NYC Industrial Development Agency (NYC IDA), an agency under the nonprofit corporation NYC EDC, administers the financial incentives. A publication of FRESH projects approved for financial incentives shows that out of 23 funded projects, the median amount of assistance awarded is $1,477,763.[7] The minimum amount that has been awarded is $27,014, whereas the maximum is $14,335,958. A bulk of the awards assist in paying state and local property taxes. For example, the awards can be used to cover a tax that is charged on all new mortgages, which typically costs up to 2.8% of the mortgage amount.[8]

The second type of incentive is a zoning incentive, examples of which include additional allowed square footage for residential use for every square foot of grocery space in mixed-use buildings, an increase in the maximum building height, and reduced requirements for parking space. In contrast to financial incentives, which are awarded on a discretionary basis, the zoning incentives are available as-of-right if the grocery store meets certain criteria, such as providing a minimum of 6000 square feet in retail space, at least 500 of which is dedicated to providing fresh foods, and displaying a sign designating the store as a FRESH beneficiary. Zoning benefits are managed by the NYC Department of City Planning (NYC DCP).

Figure 3.1 delineates FRESH areas and superimposes the boundaries on a map of NYC's census tracts as of 2010 in 4 boroughs: Manhattan, the Bronx, Brooklyn, and Queens. Staten

[7]Project information can be accessed here: `https://edc.nyc/about-nycedc/financial-public-documents`

[8]This type of tax is referred to as a mortgage recording tax. Rates differ depending on the type of property sold. The mortgage recording tax is due upfront with closing costs, akin to levying a sales tax.

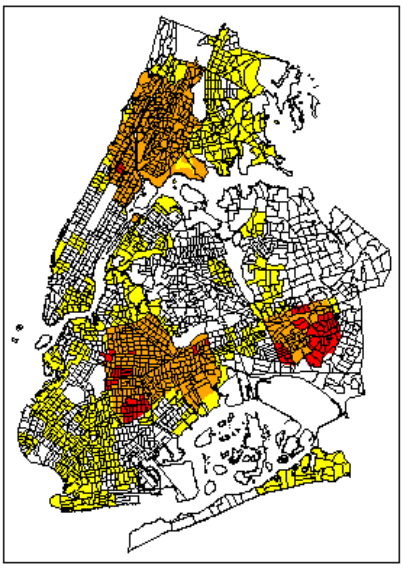

Figure 3.1: Coverage of the FRESH program across New York City. The incentives offered by the program differ depending on geography. Areas that provide only financial incentives are colored in yellow. Those that provide both incentives are colored in orange. Lastly, red areas offer only zoning incentives.

Island is omitted from the figure, and the subsequent analysis, because transaction data for properties in Staten Island are not available. The boundaries of the FRESH program and census tracts are publicly available on NYC's data repository, BYTES of the BIG APPLE. Different incentives are provided in different areas of the city. Yellow areas represent places where only financial incentives are offered by the program. In contrast, red areas represent places where only zoning incentives are offered. Places where both incentives are available are colored in orange. Relative to zoning incentives, the financial incentives are more widely available in terms of geography. Note that FRESH boundaries do not exactly conform to census tract boundaries. Instead, the boundaries are drawn based on a mix of census tract and community district boundaries, the latter of which can be thought of as a region similar to a ZIP code.

Because the incentives are managed by different groups, different criteria determine which incentives are available in any given area. The zoning incentives closely follow the Supermarket Needs Index (SNI), developed by Smith et al. (2011) for *Going to Market*. An area

exhibits a high SNI (i.e., in high need of a supermarket) if it has a high population density, is eligible for a community development block grant (a proxy for low income households), and possesses low share of fresh food retail. Instead of relying on the SNI, the state's general municipal law determines where the financial incentives are offered.[9] Specifically, census tracts, or block numbering areas, are deemed highly distressed areas if the poverty rate and unemployment rate, according to the most recent American Community Survey 5-year estimate, exceed certain thresholds.

Going to Market provides no evidence to support the claim that the lack of access to fresh groceries is caused by barriers-to-entry on the supply-side. Furthermore, no evidence is provided to suggest that addressing barriers-to-entry for grocery stores will even improve health outcomes. Nevertheless, *Going to Market* highlights several economic benefits as a result of improving access to fresh produce. One of those economic benefits is an increase in property values, which this paper directly addresses in a causal framework. Prior research is unable to establish a causal relationship between grocery stores and property values because of the endogeneity between where households locate and where grocery stores operate: a grocery store would like to operate near high-income individuals, whose neighborhoods naturally reflect high property values, but grocery stores also impact property values, as claimed by *Going to Market*. The most recent estimate is from a working paper that uses Yelp data to measure the change in the number of grocery stores for ZIP codes in 5 major metropolitan areas. The number of grocery stores is then regressed on the percentage point change in a housing price index provided by the Federal Housing Finance Agency (Glaeser et al., 2018). Controlling only for time effects, the estimate implies that an additional grocery store is associated with a 0.33 percentage point growth in the housing price index.

Figure 3.2 illustrates the intuition behind the present analysis. The panel on the left maps the census tract's quartile of average sales price for residential properties just before the

[9] Article 18-A, Title 1, Section 854, #18 at `https://www.nysenate.gov/legislation/laws/GMU/854`

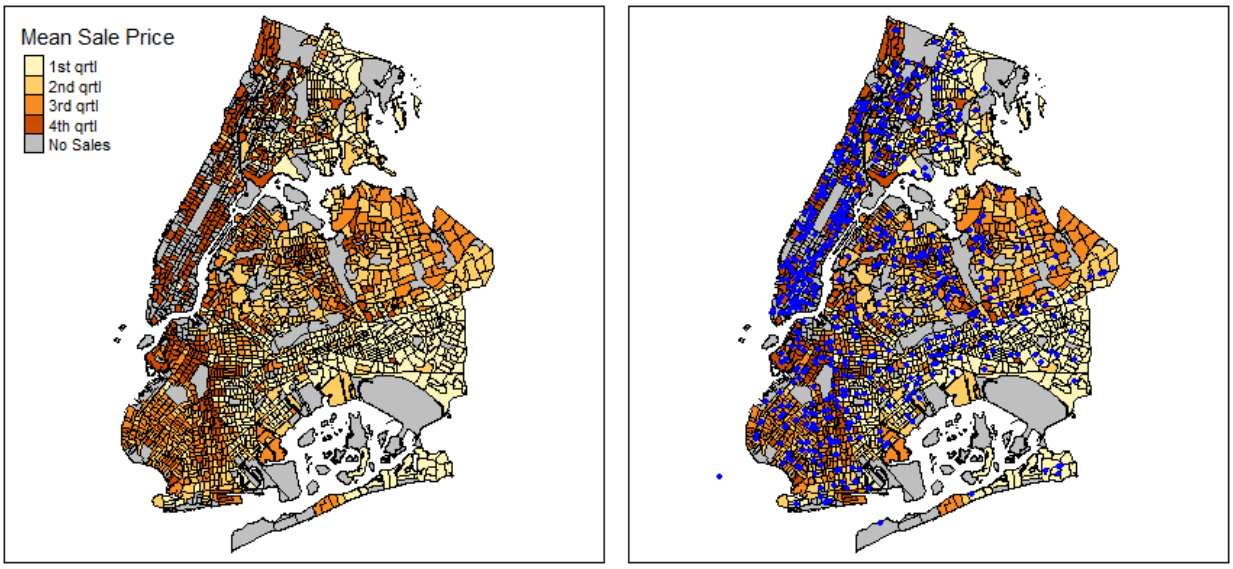

Figure 3.2: New York City census tracts as of 2010, omitting Staten Island. The panel on the left maps the distribution of average sales price in residential properties in 2008 across census tracts. The panel on the right then maps the location of grocery stores in 2008 as blue points over the distribution. Moving east from Manhattan, the average sale price declines with a decline in the concentration of grocery stores.

introduction of the FRESH program. The panel on the right overlays the location of supermarkets in 2008. Moving westward from Manhattan, average sales price declines with a decline in the concentration of supermarkets. Section 3.3 provides more details on the data for residential properties and supermarkets.

The sudden introduction of FRESH to NYC and its implementation over time present a strong case for evaluating several effects. First, a comparison of program coverage will uncover the effect of simply providing incentives to improve the local grocery environment on property values. Second, a comparison of sales surrounding stores that have opened as a result of the program over time will identify the effect of grocery stores on property values. Finally, examining related businesses surrounding FRESH stores could shed light on mechanisms behind why a grocery store influences property values. Although the results might not generalize to all neighborhoods since FRESH applies only to highly distressed areas, this paper examines an initiative to address food deserts and broader neighborhood

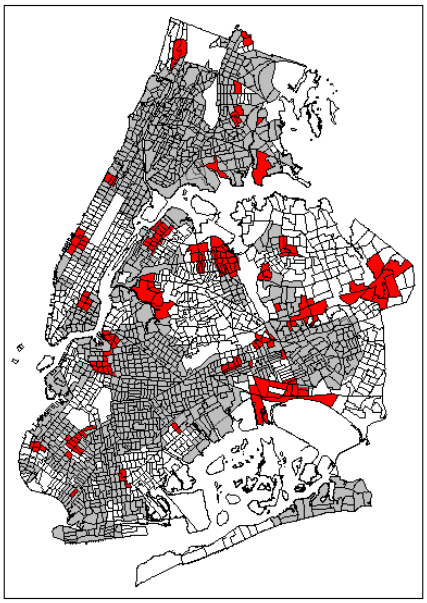

Figure 3.3: A map showing the expansion of the FRESH program. Original FRESH areas are in gray. Red areas show the expansion in 2021. Transactions occurring in the red expansion areas constitute a better control group for transactions in the initial FRESH areas because the analysis implicitly controls for selection into the program.

revitalization efforts, both of which primarily concern low-income, distressed areas.

To be precise, geographic variation over time in where incentives are offered is critical for evaluating the program's intent-to-treat effect. FRESH has undergone only one boundary change since its introduction in 2009, which was approved in 2021. Figure 3.3 maps the boundary change, highlighting newly included areas in red to contrast with the preexisting 2009 FRESH areas in gray. The change was motivated by a clustering of FRESH applications in specific communities, which could limit the effectiveness of the program in improving the local grocery environment by unnecessarily restricting the geographic reach of the program or introducing undesirably high competition among its grocery stores. To address the clustering of FRESH stores, NYC DCP expanded the program boundaries to encompass areas that had not offered FRESH incentives and remained under-served according to an updated SNI. Only zoning incentives were provided in this expansion. It is unclear whether financial benefits will be provided in the expansion areas in the future.

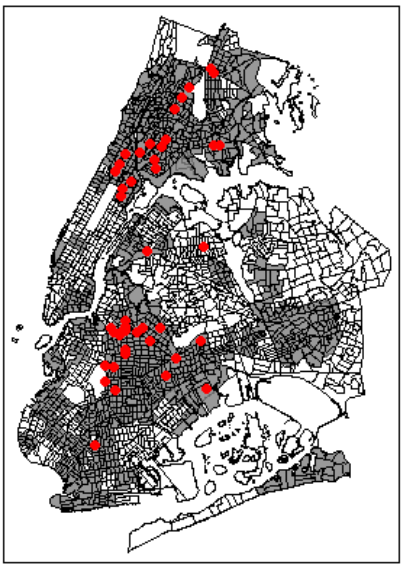

Figure 3.4: The locations of the 25 FRESH stores that have opened to the public as of 2021 (red) mapped over program areas (gray). Since its inception, the FRESH program has approved a total of 43 locations in the 4 boroughs to receive some mix of financial or zoning incentives.

Furthermore, the opening of newly constructed stores at different times presents an opportunity to isolate the value of a grocery store. Since its inception, the FRESH program has approved a total of 43 locations to receive some mix of financial or zoning incentives in the 4 boroughs under consideration. Of those 43 locations, 25 stores have opened to the public as of 2021, but only 13 can be considered newly constructed stores. Figure 3.4 maps the locations of the 25 operating FRESH stores in NYC as red points superimposed on FRESH program areas, shown in gray. The map highlights a concentration of sites in the Bronx and Brooklyn. In terms of incentives for each approved location, 6 receive both financial and zoning incentives while 17 receive only financial benefits, and 20 receive only zoning incentives. The subsequent sections provide specifics on what is considered a newly constructed store and how these openings isolate the value of a grocery store.

3.3 Data and Methodology

Correspondence with FRESH staff at NYC DCP has resulted in a list of addresses approved for zoning incentives and the year in which the sites were approved. Data on sites receiving financial incentives rely on a 2021 publication by NYC IDA that includes the site's address, year of approval, total amount of assistance awarded, and number of employees as of 2021 if opened for business. Addresses and store names of certain sites are verified by cross-referencing the information with a policy brief on the limitations of the FRESH program (Cohen, 2018) and in a city council committee report (Baker et al., 2018).

The Street View function of Google Maps allows for further verification of FRESH sites. Street View is particularly useful because it provides historical images, enabling a user to gauge when a FRESH store first opened to the public and to gauge how FRESH incentives were implemented. As such, out of all 43 locations, 25 are verified to have opened to the public as of 2021. Street View shows that 12 of those opened stores are newly constructed grocery stores, and 13 are renovations. A store is considered newly constructed if the location clearly exhibited an empty lot or construction (e.g., scaffolding) prior to the opening of a FRESH store. A store is considered a renovation if the location was home to a grocery store before the approval for FRESH incentives. The previous grocery store at a renovation site could be the same as the approved FRESH store, or it could be one from a different grocery chain. For stores with ambiguous grand openings despite Street View images, grand opening announcements via social media determine the year the stores opened to the public.

Property values are measured using transaction data from NYC's Automated City Register Information System (ACRIS). ACRIS is publicly accessible, providing information on property records beginning in 1966 to the present. However, ACRIS does not contain records for Staten Island, limiting the subsequent analysis to 4 out of the 5 boroughs of NYC. This limitation is not a concern because the FRESH program primarily applies to areas outside

of Staten Island.[10] For each property transaction, the sales price is obtained from deeds detailing the change in ownership. The transactions constitute a repeated cross-section of property sales between 2005 and 2019. Details of each property are obtained from the Primary Land Use Tax Lot Output (PLUTO) data. Provided by BYTES of the BIG APPLE, PLUTO provides insight on all tax lots in NYC between 2005 and 2019 by classifying each tax lot under a specific land use category and collecting information such as the building's year of construction, building area, lot area, and geographic coordinates.

Neighborhood characteristics are obtained from the American Community Survey (ACS) 5-year estimates for the corresponding study period. Because the ACS pools data from each year in the 5-year interval, every 5-year interval is time invariant—the estimated characteristics are assumed to not vary within each 5-year interval.[11] Despite the limited variation in neighborhood characteristics, these measures are vital in accounting for broader factors that influence property values. Such factors commonly include neighborhood racial composition, college-educated population, and per capita income. Census tract boundaries are harmonized to 2010 boundaries using the Longitudinal Tract Data Base (Logan et al., 2014).

Lastly, data on retail businesses are obtained from proprietary data between 2005 and 2018. Data Axle, formerly known as InfoGroup, collects information on businesses in their ReferenceUSA Historical Business dataset. ReferenceUSA includes addresses, self-reported SIC classification, the number of employees, and the sales for each observed establishment in a given year. The information is verified by a phone interview. While ReferenceUSA is the most comprehensive retail survey, it is by no means complete: new businesses are possibly omitted depending on timing of the survey and whether a phone interview is completed. Nonetheless, it captures the retail environment quite well, as shown in the following subsec-

[10] FRESH primarily applies outside of Staten Island in a geographic and programmatic sense. More area is covered in the other 4 boroughs, and only 1 store, not counted as part of the 43, has opened in Staten Island (300 Sand Lane).

[11] All dollar values in this paper are in terms of 2019 dollars. Dollar values are adjusted using the average CPI-U for New York-Newark-Jersey City, with 1982-1984 as the base.

tion.

The data are all connected via geocoding. PLUTO already provides geographic coordinates for properties based on block and lot numbers. Businesses from ReferenceUSA are geocoded based on address and ZIP code using both the US Census geocoder and NYC GeoSearch, accessed via R. Geocoding permits the properties or businesses to be tied to census tract characteristics in the ACS. Moreover, geographic location in conjunction with year determine treatment status.

3.3.1 Stylized Facts

Table 3.1: SIC Codes of FRESH Stores

SIC Code	SIC Description
541101	Food Markets
541103	Convenience Stores
541105	Grocers-Retail
542101	Seafood-Retail
542107	Meat-Retail

Notes: The SIC codes corresponding to FRESH stores that have opened to the public. The inclusion of convenience stores might seem odd, but the definition of grocery stores in this paper also takes into consideration number of employees to exclude small convenience stores and liquor shops, which presumably require a smaller staff.

The data must reflect several key features, the first being general time trends in the number of grocery stores to corroborate anecdotes about NYC. For the purposes of this study, a grocery store is a business that conducts its primary line of business according to one of the SIC codes in Table 3.1 and employs at least 10 individuals. This definition is derived according to land use regulations and revealed preference by the FRESH program. Food

stores are defined by land use regulations as retail stores and personal service establishments including supermarkets, grocery stores, meat markets, or delicatessens.[12] There are SIC codes that correspond to this definition, but to be exact about the types of stores that the FRESH program targets, the 25 stores that have opened to the public are matched as closely as possible to stores found in ReferenceUSA. The result is the list of SIC codes shown in Table 3.1 describing the primary line of business for these stores.

Table 3.1 includes convenience stores, which might seem odd given that FRESH aims to develop or renovate retail space of at least 5000 square feet with a minimum of 500 square feet for fresh foods. The typical notion of a convenience store is a small store with a limited selection of fresh foods, if there is any at all. ReferenceUSA does not collect information on square footage, but it does include a self-reported number of employees for a particular business. Locations that do not report a number of employees have an estimated measure based on comparable businesses in the area. According to the employment information for FRESH stores receiving financial incentives, the minimum full-time equivalent employment is 10 employees.[13] Hence, a grocery store in this paper must employ at least 10 employees.

Based on this definition of a grocery store, Figure 3.5 plots the count of grocery stores in FRESH areas versus non-FRESH areas across the study period (colored areas versus non-colored areas in Figure 3.1). Indeed, non-FRESH areas exhibit more grocery stores than FRESH areas, supporting the claim of limited access to fresh foods in the study, *Going to Market*. A vertical black line indicates the introduction of the FRESH program, and there looks to be a steeper incline in the number of grocery stores for FRESH areas in the few years following the introduction of the program. Then in 2015, there is a city-wide decline in the number of supermarkets, matching the anecdotes of major supermarket chain closures throughout the city. *The New York Times* discusses closures due to increasingly high rents

[12] A precise definition is provided in use group 6 in the NYC zoning regulations: Article III, Chapter 2, 32-15

[13] Full-time equivalent is calculated as # FTE + 0.5∗# PTE, where FTE stands for full-time employment and PTE stands for part-time employment.

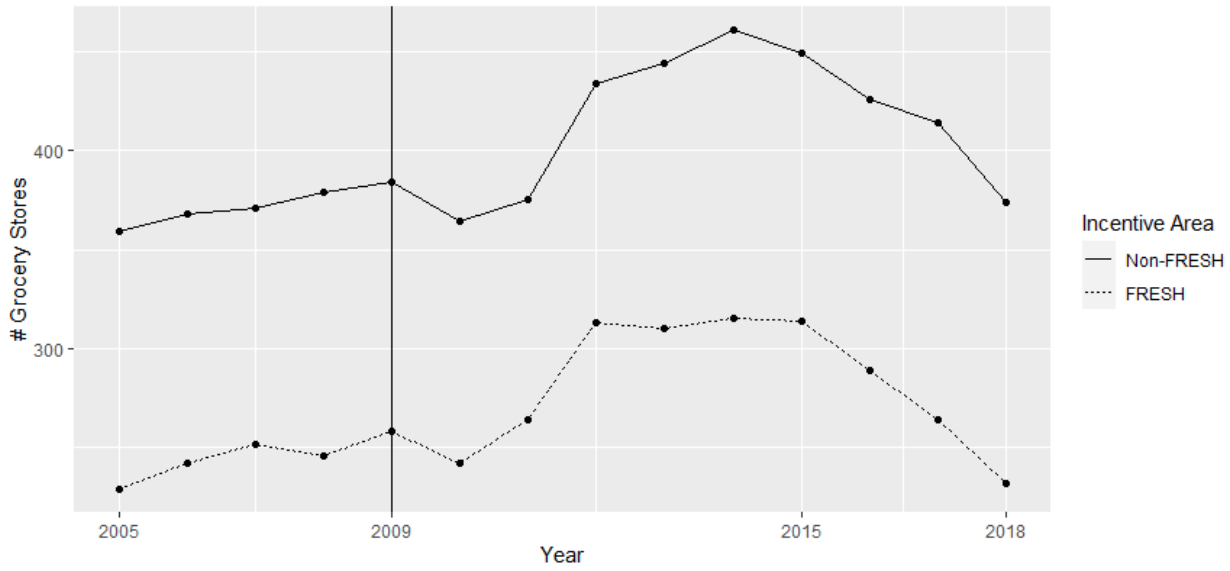

Figure 3.5: The number of grocery stores in FRESH areas versus non-FRESH areas over the study period. A vertical black line at year 2009 denotes the introduction of the program to NYC. Non-FRESH areas exhibit more grocery stores than FRESH areas, supporting the concern over food deserts in select areas of the city. After the introduction of the FRESH program, there seems to be a steeper incline in the number of grocery stores in FRESH areas compared to non-FRESH areas. In 2015, there is a city-wide decline in grocery stores, matching anecdotes of major supermarket chain closures throughout the city.

and competition. For example, The Great Atlantic & Pacific Tea Company, a large grocery store chain, filed for bankruptcy in 2015, signifying difficulties in the grocery industry for even the most established businesses. Other possible explanations for grocery store closures can include the continuation of shifting trends towards eating out, as discussed in *The Atlantic*.

One concern could be that FRESH areas are less populated than non-FRESH areas, making the issue of having fewer grocery stores moot. By counting the number of grocery stores for each census tract in a given year and using population data from the ACS, it is possible to create a density measure. The attention here is placed on census tracts that are fully contained within FRESH boundaries and on tracts that are completely outside of FRESH boundaries, to avoid possible contamination by program offering. Figure 3.6 compares the average number of people served by a grocery store between the two areas. The average is taken across census tracts. Notably, the average number of people served by a grocery store

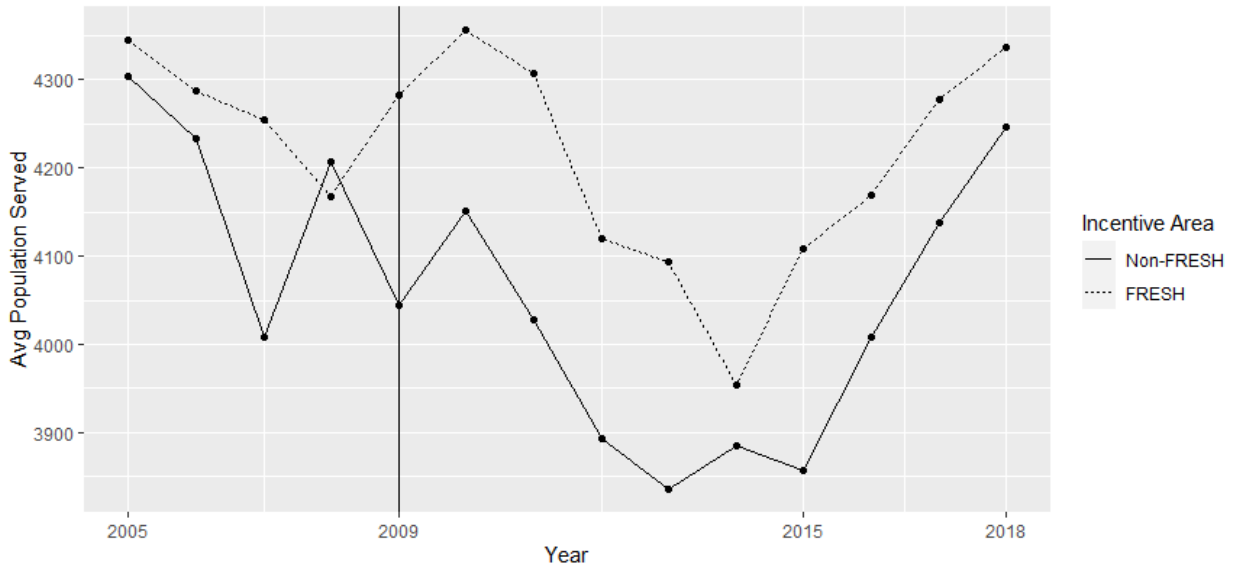

Figure 3.6: This figure plots the average density of grocery stores across census tracts over time. Density of grocery stores is defined to be the size of the population served per grocery store in a given census tract, so an increase in density is not desirable from the standpoint of food deserts. Only census tracts that are fully contained in program areas or that are completely outside of program areas are included to avoid ambiguous treatment coverage. Notably, the average number of people served by a grocery store in FRESH areas is greater than that in non-FRESH areas, except in 2008. The overall trend adds more evidence to support the concern over food deserts in select parts of the city.

in FRESH areas is consistently greater than that in non-FRESH areas, except for one year. Most of the variation in this density measure is from the number of grocery stores, rather than population, because population is held constant within each ACS 5-year period. Thus, the data reflect limited access to fresh foods in areas of concern because the average census tract within FRESH boundaries is home to fewer grocery stores, meaning more people must be served by any one grocery store.

Given that only 25 FRESH stores in all of NYC have begun operation since the program was introduced in 2009, FRESH might seem limited in its impact. However, correspondence with FRESH staff suggest an alternate avenue for impact: some developers interested in applying for incentives ultimately decide not to pursue them for various reasons. Unfortunately, there is no record of developers who ultimately choose not to pursue the program, but this

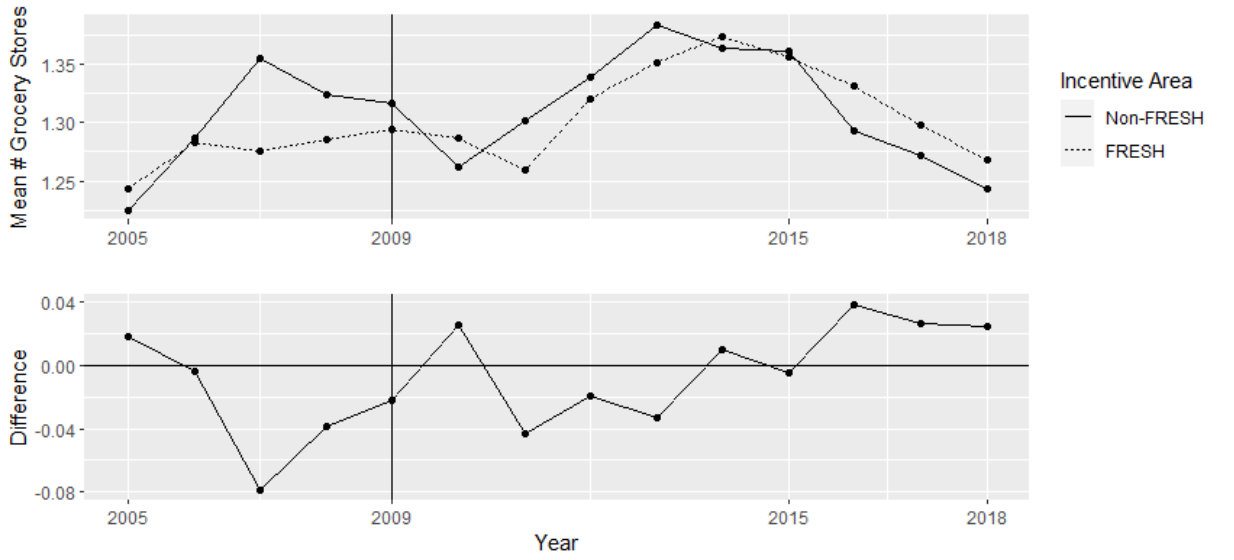

Figure 3.7: Top: a plot of the average number of grocery stores across census tracts. Bottom: a plot of the difference in average number of grocery stores between the areas. The steady attenuation of the difference suggests that the FRESH program is associated with a general increase in the number of grocery stores and sustaining those businesses from closure over time. FRESH staff have noted an active interest in the program, but some developers who inquire do not follow through for various reasons. This figure corroborates their story and highlights how the program does not need to be actively implemented to have an impact because it nevertheless generates interest in applicable areas.

anecdote suggests that FRESH piques developers' interest in these areas. These areas are particularly attractive because the impetus for the program naturally implies weak grocery store competition. Not taking benefits does not necessarily preclude the developers from building. In other words, the development of grocery stores still could have occurred.

The top panel in Figure 3.7 plots the mean number of supermarkets across census tracts, once again distinguished by program area and eliminating tracts with ambiguous treatment coverage. The bottom panel in Figure 3.7 plots the difference between the averages. It seems that the FRESH program is associated with a general increase in the number of grocery stores over time. The steady increase is graphical evidence to support the view that the program does not need to be actively applied to have an impact. Thus the, anecdotes from FRESH staff seem to be credible, motivating the empirical strategy in the following subsection.

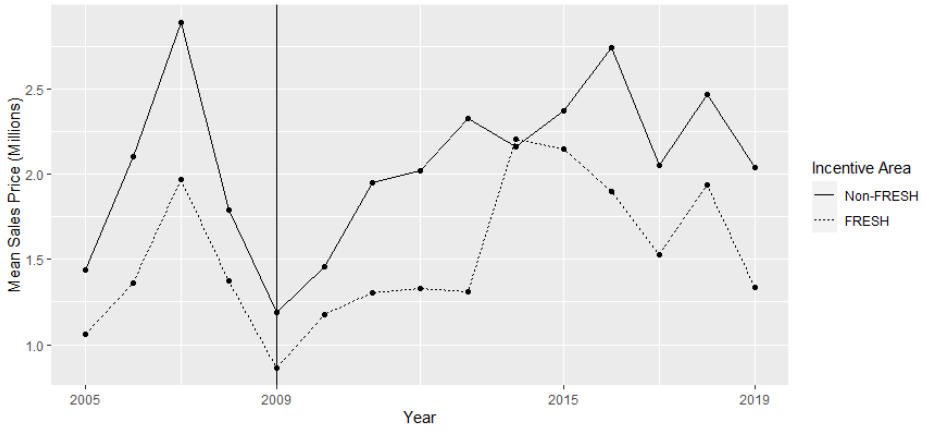

Figure 3.8: The mean sales price of residential property in millions of USD across the study period, broken down by program area. A vertical black line indicates when NYC introduced FRESH. Trends are visually similar up to 2009, then diverge a couple of years afterwards. Sales price in FRESH areas seem to catch up in 2014 before gradually declining.

3.3.2 Empirical Strategy

This paper is most interested in the effect of grocery stores on residential property values. *Going to Market* ambiguously claims that property values will increase. Given the main purpose of FRESH, improving the quality of life for residents in program areas, there should be an observable improvement in local amenities. Improvements to local amenities are thought to be capitalized into property values because when a neighborhood becomes more desirable, more residents will move in, driving residential property values higher. Hence, the analysis will focus primarily on residential property values, measured by sales price from ACRIS.

The empirical strategy is motivated by the program's variation in geographic coverage and timing of store openings. Because program coverage and store locations are non-randomly chosen, a difference-in-difference model is best suited to establish the effect on property values using the compiled observational data. Figure 3.5 indicates that the necessary parallel trends assumption graphically holds, at least in the number of grocery stores. Plotting average sales price by program area in Figure 3.8 also visually indicates parallel trends in property values.

Table 3.2: Mean Sales Price (millions USD) of Residential Property

	Before FRESH	After FRESH	DD
Control	1.010	1.083	
	(0.0416)	(0.0435)	
Treated	0.975	1.157	
	(0.0404)	(0.0508)	
Difference	-0.0353	0.0735	0.109
	(0.0580)	(0.0668)	(0.0585)

Notes: Standard errors clustered by census tracts in parenthesis. This table reports means after accounting for seasonal effects (month of sale), time effects, and census tract fixed effects. The diff-in-diff coefficient is significant at the 10% level.

Namely, trends are visually similar before 2009, then diverge a couple of years afterwards. A more rigorous test of pre-trends is provided with the results in the subsequent section.

Indeed, Table 3.2 further motivates implementing a difference-in-difference estimation strategy. By comparing the sales price of residential properties in program areas to that of residential properties outside program areas, a marginally significant coefficient emerges after accounting only for tract fixed effects, year effects, and seasonality (month of sale). The estimate suggests that properties within FRESH boundaries sell for $110,000 more than if the program were never introduced. While the estimate in Table 3.2 is not causal for various reasons, it suggests that trends diverge in an observable manner, from which a causal effect could be derived.

The differences in trends is formalized in a difference-in-difference model for a repeated cross-section of property transactions between 2005 and 2019:

$$Log(SalesPrice)_{ict} = \beta_0 + \beta_1 Post_{it} \times Treat_{ic} + \beta_2 Tract_c + \beta_3 Year_t + \beta_4 Month_{it} + \beta_5 X_{ict} + \epsilon_{ict}\,, \tag{3.1}$$

where i indexes properties, c census tracts, and t years. Equation 3.1 controls for tract fixed effects $Tract_c$, time effects $Year_t$, seasonal effects $Month_{it}$, and time-varying neighborhood and property characteristics X_{ict}. The property's month of sale proxies for seasonal effects. Neighborhood and property characteristics include the year that the property was built, its approximate square footage, racial composition of the neighborhood, the share of population that is college educated, and the neighborhood's per capita income. The identifying variation is changes in sales price over time within each census tract. $Post_{it}$ is a dummy variable that takes a value of 1 after treatment occurs. $Treat_ic$ is also a dummy variable, taking a value of 1 if a property belongs to the treatment group. Hence, the coefficient of interest is β_1, which reflects the difference-in-difference.

Equation 3.1 serves as the basis for two different regression analyses. The first is the intent-to-treat analysis, where property sales over the 2005-2019 period are used and where the treatment group is all properties in FRESH areas designated by the program in 2009. The control group consists of properties in new FRESH areas designated in 2021, whose presence in an eventual FRESH area presumably makes them similar to properties in the original FRESH area. The $Post_{it}$ dummy variable equals one during the initial FRESH period, 2009-2019, and equals zero during the period prior to FRESH, 2005-2008.

The second regression based on Equation 3.1 again uses 2005-2019 sales transactions, and the treatment group consists of properties that lie within 0.5 miles of a grocery store opened under FRESH prior to 2021, while the control group consists of properties lying between 0.5 and 1.0 miles from a FRESH store. $Post_{it}$ is now a dummy equal to one after the opening of the nearby FRESH store and zero before the opening. Note that, while the $Post_{it}$ dummy in the intent-to-treat regression lacks a parcel subscript, just depending on time, the dummy is both parcel and time specific in the store-proximity regression. The features of the two regressions are discussed further below.

3.4 Results

3.4.1 Intent-to-treat results

The first foray into examining the causal impacts of a grocery store on residential property values is to see whether providing the FRESH program alone is enough to influence property values. This could occur in a variety of ways, one being that future homeowners learn about the potential for a new, nearby grocery store. The potential for improved amenities might be enough to incentivize future homeowners into purchasing property in an area that they would not have considered if the FRESH program had not been introduced. Furthermore, establishing this effect is important from an intent-to-treat perspective. If such an effect exists, then the FRESH program could possibly meet broader neighborhood revitalization goals aside from improving the local food environment without actually leading to the construction of grocery stores. However, a direct comparison of program areas to non-program areas is challenged by unobserved factors that jointly determine property values and selection into FRESH. For instance, neighborhoods with more health-conscious residents will attract grocery stores, thereby influencing property values. Likewise, the FRESH program would not apply to said neighborhood. Any estimated effects from comparing program areas to non-program areas could be biased by inherent differences between the areas.

To ensure a proper comparison, Equation 3.1 is estimated based on changes in the geographic coverage of the FRESH program, as explained above. Figure 3.3 illustrates the change: gray represents areas that were initially approved in 2009. The areas that were later approved in 2021 are in red. Hence, the analysis uses a sample of residential property transactions that fall within either of these colored areas. Transactions in the red areas constitute the control group because they are considered as never-treated within the study period, 2005 to 2019. The treatment group consists of transactions in the gray areas, treatment being

the introduction of the FRESH program in 2009. There are 126,828 unique properties transacted in this scenario. This estimation procedure ensures a proper comparison because it reflects neighborhoods that will fall under the FRESH program at some point in time. The eventual inclusion means that neighborhood factors in the control group, both observed and unobserved, are similar to neighborhood factors in the treatment group (that is, similar enough to be included within FRESH boundaries).

Table 3.3 reports the results of estimating Equation 3.1 using a sample reflecting only the colored areas of Figure 3.3. Standard errors are clustered at the tract level. Column 1 captures a general comparison of treatment versus control observations, while each subsequent column defines treatment as the introduction of specific types of incentives in 2009, such as offering only financial incentives. According to the estimate in Column 1, sales prices for residential properties increased by 13.2% due to the introduction of FRESH. The increase in sales price is consistent throughout all treatments except for Column 4, when treatment is defined as offering only zoning incentives. A lack of statistical significance shows that control and treatment groups exhibit no sales price differences when treatment is defined as offering only zoning incentives. Columns 2 and 3 represent areas that offer only financial incentives and areas that offer both incentives, respectively. Because an observable sales price effect seems to appear only when treatment includes financial incentives, it could be that financial incentives are more appealing than zoning incentives, thereby inducing a stronger reaction in prices. The strongest effect, at 18%, is observed in areas that offer both incentives.

Back of the envelope calculations state these estimates in real terms. The mean sales price in the treatment group before 2009 is about $988,572. A 13.2% increase is then an increase in sales price of about $130,492. Applying this increase to the 41,318 unique properties in the treatment group before 2009 leads to a total increase in value of over $5.3 billion.

An event study supports the parallel trends assumption for the specification in Column 1 of Table 3.3. It does so by estimating the difference in average sales price between the

Table 3.3: Intent-to-treat results using geographic variation of FRESH

VARIABLES	(1) Overall	(2) Financial-Only	(3) Both Incentives	(4) Zoning-Only
DD	0.1320***	0.1427***	0.1803***	-0.0424
	(0.0340)	(0.0357)	(0.0436)	(0.0451)
Year Built	0.0004**	0.0006**	0.0002	0.0005
	(0.0002)	(0.0003)	(0.0002)	(0.0004)
% White	0.0024*	-0.0035**	0.0055***	0.0003
	(0.0013)	(0.0014)	(0.0019)	(0.0025)
% College Grad	0.0023	-0.0031	-0.0007	-0.0020
	(0.0020)	(0.0022)	(0.0031)	(0.0032)
% Vacant Housing	-0.0049**	0.0004	-0.0065**	0.0001
	(0.0020)	(0.0024)	(0.0027)	(0.0030)
% Rental Housing	0.0016	0.0018	-0.0003	0.0001
	(0.0015)	(0.0018)	(0.0022)	(0.0025)
% Unemployed	-0.0036	-0.0058*	-0.0027	-0.0013
	(0.0025)	(0.0031)	(0.0033)	(0.0044)
Logged Income per Capita	0.4303***	0.1741**	0.4629***	0.4109***
	(0.0755)	(0.0848)	(0.1044)	(0.1480)
Constant	7.6438***	10.3395***	7.7653***	7.7377***
	(0.8681)	(1.0796)	(1.1532)	(1.7932)
Observations	179,538	92,067	97,811	49,414
Tract FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Month FE	YES	YES	YES	YES
Clusters	1176	636	637	236

Standard Errors clustered by census tracts in parenthesis
*** p<0.01, ** p<0.05, * p<0.10

Notes: The dependent variable in all specifications is the logged sales price of a property. Further, the data contain only properties that are zoned for residential use. Each specification uses transactions in areas that will become eligible to receive FRESH incentives in 2021. Treatment is the introduction of the original program in 2009. The program raises sales price in all areas except for those offering only zoning benefits. Areas that offer both benefits experience the strongest increase in sales price.

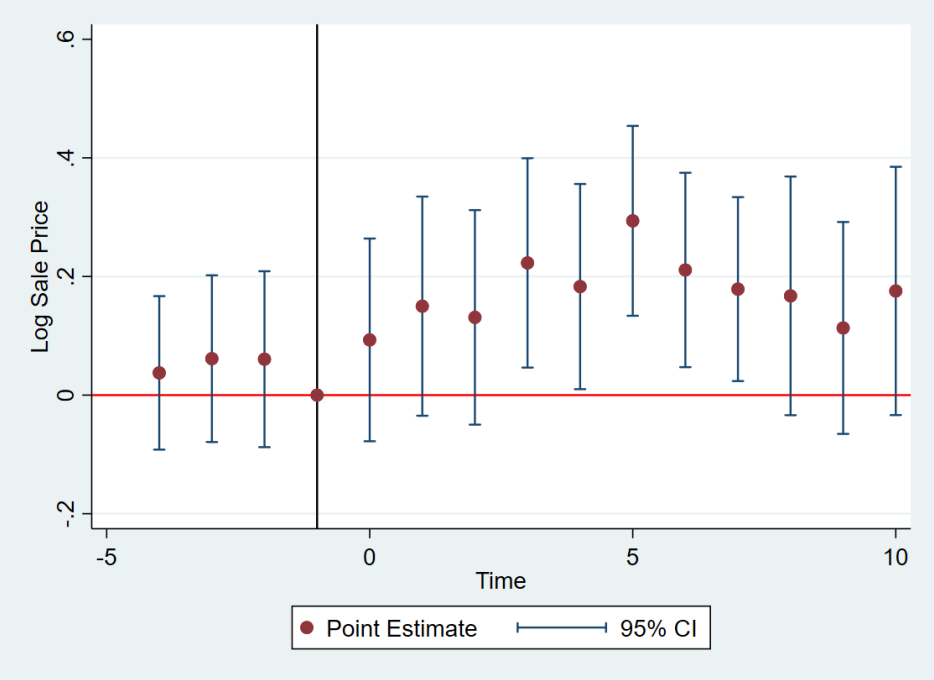

Figure 3.9: The event study corresponding to the intent-to-treat results obtained from a difference-in-difference specification that makes a comparison based on geographic variation over time in where incentives are offered. The differences in the average sales price between the treatment and control groups for each year are captured by coefficients on dummies representing each yearly comparison. Because the dummy for 2008 is omitted, the coefficients are relative to the difference that is observed in 2008. Confidence intervals at the 95% level based on standard errors clustered by census tracts are plotted around the point estimates. All years before 2008 do not exhibit a statistically significant coefficient, suggesting that the parallel trends assumption is reasonable. In contrast, a significant and positive effect emerges in 2012 ($t = 3$). The positive effect is sustained for 4 more years before losing its statistical significance in 2017 ($t = 8$).

treatment and control groups for each year before and after treatment occurs. The differences are captured by coefficients on dummies representing each yearly comparison. By omitting 2008, one year before treatment, each coefficient is interpreted as the difference relative to what can be observed in 2008. Hence, if notable pre-trends exist between the treatment and control groups, then a statistically significant coefficient should emerge for any year prior to 2008. Figure 3.9 plots the coefficients of interest in the event study, after adjusting for all the covariates listed in Table 3.3. Time $t = 0$ denotes 2009, $t = 1$ corresponds to 2010, and so forth. Confidence intervals at the 95% level based on standard errors clustered by census tracts are plotted around the point estimates. In this case, all years before 2008 do not

exhibit a statistically significant coefficient, suggesting that the parallel trends assumption is reasonable. In contrast, a significant and positive effect emerges in 2012 ($t = 3$). The positive effect is sustained for 4 more years before losing its statistical significance in 2017 ($t = 8$). This pattern coincides with what is observed in Figure 3.8: a noticeable jump in sales price does not occur until 2014 before prices again conform to the common trend in sales price. Although not included, event studies corresponding to Columns 2 and 3 of Table 3.3 also support the parallel trends assumption for those specifications.

Hesitancy regarding the program might possibly explain the lagged response. A 2015 report[14] by the Healthy Food Retail Action Network on the impact of FRESH highlights that developers were initially hesitant to apply for benefits. The cited reason for hesitancy is deeply ingrained perspectives on working with city government. This obstacle was overcome by active outreach and information sessions with community and industry stakeholders. Seeing that the outreach and information sessions have overturned negative opinions of the program, as evidenced by the 43 approved sites, there is reason to believe that there was initial apprehension and stigma involving FRESH.

3.4.2 Store-proximity results

The prior analysis identifies the intent-to-treat effect of the FRESH program, so to specifically estimate the causal effect of a grocery store on residential property values, the attention is turned to property transactions within the vicinity of newly constructed stores that have opened to the public at different times. Essentially, if the location clearly exhibited an empty lot or construction prior to the opening of the FRESH store, then it is considered a new construction. There are 12 newly constructed grocery stores out of the 25 stores receiving FRESH incentives that have opened to the public as of 2021. The treatment group

[14]Available at `https://healthyfoodretailnyc.org/wp-content/uploads/2018/04/FRESH-Food-Retail-Expansion-to-Support-Health-Program-Impact-Report.pdf`

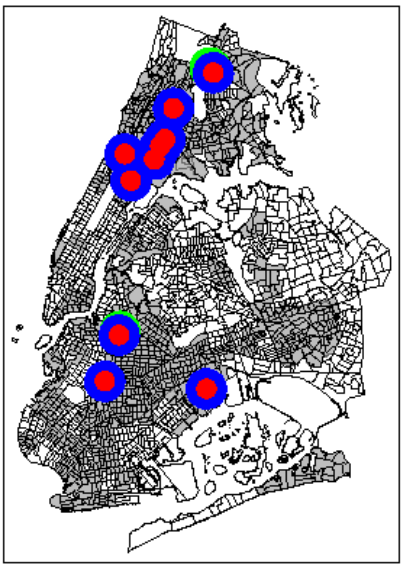

Figure 3.10: This figure illustrates the comparison underlying the store-proximity results. The treatment group now consists of properties within 0.5 miles of a newly constructed grocery store, as opposed to the control group that now consists of properties between 0.5 to 1 miles away from the same store. Concentric circles, the centers of which are the newly constructed stores, capture the areas under consideration. Red areas represent areas within half a mile of a newly constructed store, whereas blue areas represent areas that fall between half a mile to 1 mile of a newly constructed store. Two locations in the data have yet to open by the last year in the study period, 2019, so all properties within 1 mile of those locations, but at least half a mile away from an opened FRESH store, are considered as part of the control group. These properties fall in the green areas.

now consists of properties within 0.5 miles of a newly constructed grocery store, as opposed to the control group that now consists of properties between 0.5 to 1 miles away from the same store. Figure 3.10 illustrates the comparison using concentric circles, the centers of which are the newly constructed stores. Half a mile is chosen as the cutoff because it is commonly believed to be a 10-minute walk.[15] Treatment occurs in the year that a newly constructed grocery store opens to the public. Two locations in the data have yet to open by the last year in the study period, 2019, so all properties within 1 mile of those locations, but at least half a mile away from an opened FRESH store, are considered as part of the control group. The credibility of this comparison relies on believing that each newly constructed

[15]The National Park Service and Centers for Disease Control and Prevention use this measure when discussing park access and public health (Merriam et al., 2017).

grocery store would not exist if it were not for the FRESH program. Nonetheless, using store openings over time to facilitate the analysis controls for the selection process in determining the location of a grocery store. Properties around these areas are therefore likely to be similar in nature.

Table 3.4 reports the results of comparing properties near a FRESH store to those farther away from the store using the same covariates as before, but now relying on robust standard errors instead of clustered standard errors. Clustered standard errors are not possible under these specifications because the limited number of FRESH stores is not sufficient to justify a proper estimation of clustered standard errors. Column 1 estimates an 11.75% increase in sales price because of a newly constructed grocery store, although this estimate is marginally insignificant with a p-value of 0.106. The estimated sign is as expected. For greater context, the estimate could be compared to the results from implementing the same specification on properties around the 13 renovation sites. Column 3 performs the same estimation procedure as Column 1, but for sites that are considered renovations rather than new construction. In this case, the estimated sign is not as expected and the estimate is far from statistically significant. Comparing Column 1 to Column 3 supports the notion that grocery stores raise property values.

Alternatively, assessed property values could be used as a proxy for value instead of sales price because assessed values are presumably taken into consideration by both buyers and sellers of real estate. Assessed property values are provided by PLUTO for each transacted property. The NYC Department of Finance derives assessed property values for residential properties from an estimate of market value.[16] The market value is estimated based on the market approach recommended by the International Association of Assessing Officers (IAAO).[17] This recommended approach examines comparable sales, typically stratified by

[16]Year to year changes in assessed values in PLUTO are not capped because they are based on estimated market value. These changes are capped only when calculating a homeowner's property tax, which is unnecessary in this study.

[17]Marketproof, a real estate intelligence and analytics company focused on NYC, describes the mass ap-

Table 3.4: Store-proximity results using newly constructed stores

VARIABLES	(1) New Constr. Sales Price	(2) New Constr. Assessed Value	(3) Renovations Sales Price	(4) Renovations Assessed Value
DD	0.1175	0.0793***	-0.0135	-0.0080
	(0.0727)	(0.0273)	(0.0501)	(0.0161)
Year Built	0.0009**	0.0014***	-0.0000	0.0010***
	(0.0005)	(0.0002)	(0.0002)	(0.0001)
% White	0.0051***	0.0037***	0.0040***	0.0057***
	(0.0010)	(0.0003)	(0.0006)	(0.0002)
% College Grad	0.0044	0.0041***	0.0026	0.0023***
	(0.0028)	(0.0010)	(0.0020)	(0.0007)
% Vacant Housing	-0.0274***	-0.0127***	-0.0125***	-0.0091***
	(0.0037)	(0.0013)	(0.0020)	(0.0005)
% Rental Housing	0.0090***	0.0073***	0.0043***	0.0065***
	(0.0013)	(0.0006)	(0.0008)	(0.0003)
% Unemployed	-0.0011	-0.0000	-0.0000	-0.0064***
	(0.0033)	(0.0012)	(0.0028)	(0.0009)
Logged Income per Capita	0.6036***	0.1244***	0.4532***	0.2419***
	(0.0917)	(0.0313)	(0.0641)	(0.0194)
Constant	4.3337***	5.3851***	7.9697***	5.1047***
	(1.3171)	(0.5554)	(0.7399)	(0.3420)
Observations	31,665	31,639	53,456	53,440
Store FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Month FE	YES	YES	YES	YES

Robust standard errors in parenthesis
*** p<0.01, ** p<0.05, * p<0.10

Notes: All dependent variables are logged. The sample contains only properties that are zoned for residential use. A property is considered treated if it is sold within 0.5 miles of FRESH store that has opened to the public. Each specification uses transactions occurring 0.5 to 1 mile away from the FRESH store as a control. For Columns 1 and 2, there are two new construction sites that have yet to open to the public as of the study period. Those two sites also constitute the control group. New supermarkets raise surrounding property values, as evidenced by comparing the first two columns to the latter two columns (new construction sites versus renovation sites). The best estimate of the rise in property values is 7.9%, reported in Column 2.

area. More importantly, the relevant residential property characteristics described by IAAO do not explicitly account for retail environment. The closest characteristic listed by the approach is, "Market area, zone, and neighborhood." Thus, an improvement to the retail environment, such as opening a grocery store, does not mechanically increase assessed property values.[18]

Column 2 of Table 3.4 captures the effect of a newly constructed grocery store on assessed values. A newly constructed store leads to an average increase of 7.93% in assessed value, and this estimate is highly significant. For renovation sites in Column 4, there is not a significant effect on assessed values, further supporting the relevance of an observed effect for newly constructed grocery stores. While this does not reflect a direct increase in sales price, an increase in assessed value could lead to a higher selling price in the future, insofar as buyers and sellers of real estate consider property assessments. Moreover, an increase in assessed values leads to an expansion of the city's tax base. Property tax represents 48% of the tax revenue collected by NYC, at least in fiscal year 2021. The majority of tax revenues fund important public services such as police agencies, fire departments, education, and public health, so this effect still possesses relevant implications.[19]

The parallel trends assumption for assessed values seems reasonable, according to the corresponding event study plotted in Figure 3.11. Under this specification, treatment occurs at different times depending on when a new store first opens to the public. Time in Figure 3.11 now reflects the number of years before or after the opening of a new store (e.g., $t = 1$ means 1 year after opening). Nevertheless, the principles of the event study remain the same because the year immediately before treatment occurs is omitted. If pre-trends exist,

praisal methods used by NYC at `https://blocksandlots.com/wp-content/uploads/2020/01/New-York-City-Property-Tax-System-Background.pdf`. The precise guidance on mass appraisals can be found at `https://www.iaao.org/media/Standards/International_Guidance.pdf`.

[18]Assessed values do not mechanically increase from year to year either, as shown when comparing assessed values year to year in PLUTO.

[19]NYC reports how it uses revenues from property tax in this brochure: `https://www1.nyc.gov/assets/finance/downloads/pdf/brochures/class_1_guide.pdf`

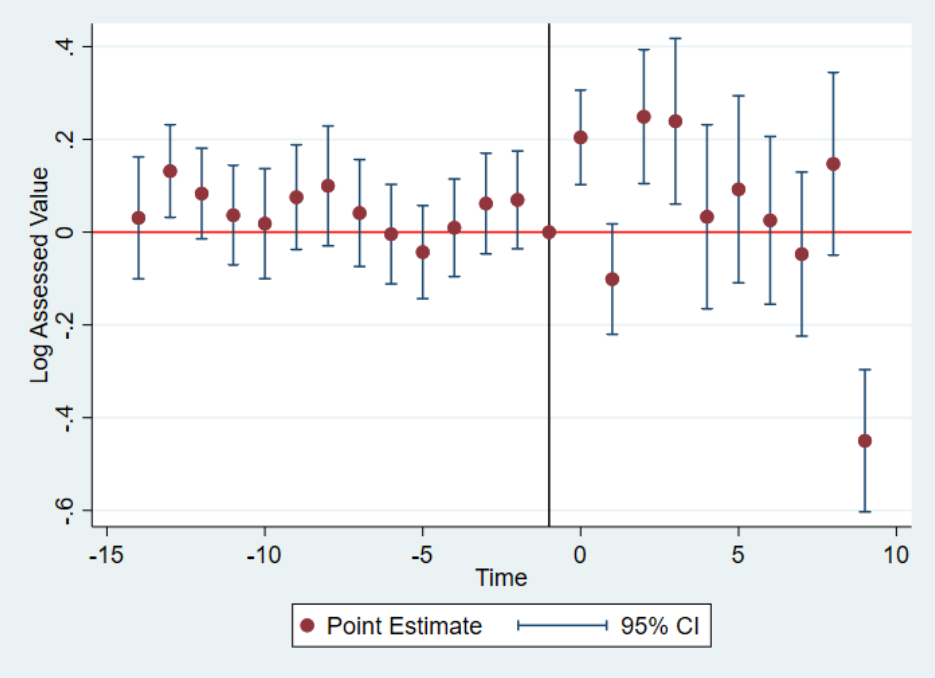

Figure 3.11: The event study corresponding to the store-proximity results, specifically Column 2 of Table 3.4. As in the event study corresponding to the intent-to-treat results, the differences in the average assessed values between the treatment and control groups for each year are captured by coefficients on dummies representing each yearly comparison. However, treatment now occurs when a newly constructed store first opens to the public. Because the dummy for the year prior to a store opening is omitted, the coefficients are relative to the difference that is observed just before a store opens. Confidence intervals at the 95% level based on robust standard errors are plotted around the point estimates. All years prior to opening, except one, do not exhibit a statistically significant coefficient, suggesting that the parallel trends assumption is reasonable. A significant and positive effect emerges after the reference period, followed by a decreasing trend.

then significant coefficients will emerge for any of the years prior to $t = -1$. The event study adjusts for the same covariates as Column 2 of Table 3.4 and relies on robust standard errors. All the time periods prior to $t = -1$, except for one at 13 years prior, exhibit a lack of statistical significance. In light of a significant and positive effect after the reference period, it seems that assessed values for these properties likely trended similarly up until a new store opened to the public. The average effect is positive, but a decreasing trend in the years after an opening suggests heterogeneous effects over time.

3.5 Indirect Effects

A justification for the FRESH program in *Going to Market* points to an indirect effect of grocery stores on property values. *Going to Market* specifically claims that full-line food stores are high-value magnets that attract complementary stores and services. In this way, a grocery store has the potential to indirectly improve local amenities, thereby indirectly increasing property values, because of spillover effects from the grocery industry into complementary businesses. One such complementary business is eating and drinking places, which includes bars, cafes, and restaurants.

ReferenceUSA provides a look into eating and drinking places between 2005 and 2018 that are likely to locate near full-line food stores. The businesses under consideration fall under the broad categories of retail bakeries; eating and drinking places, including establishments that serve alcohol; and retail candy, nut, and confectionery stores. Such a business is included in the sample if it reports conducting any of these activities, not necessarily as a primary line of business. For ease of discussion, any establishment partaking in these activities will henceforth be collectively referred to as restaurants. There are 364,570 distinct observations of restaurants in the sample across the entire study period.

Restaurants are often discussed in the literature on gentrification in association with property values. Glaeser et al. (2018) recently estimated correlations between the number of Starbucks and the growth in house prices using Yelp data. While not causal, the positive association indicates that an additional Starbucks is associated with a 0.5% increase in housing prices. This finding exemplifies the existence of an interaction between food retail as a local amenity and house prices. The idea that restaurants influence house prices is not new: Brueckner et al. (1999) discuss the same idea and provide a theory for how amenities determine the location choice of high-income households relative to low-income households, thereby determining house prices.

To add credence to the claim in *Going to Market*, the data must show that restaurants are more likely to locate near grocery stores. Taking a census tract to represent a neighborhood in NYC, the number of grocery stores and restaurants are collected for each census tract in a particular ACS survey period. After accounting for the same covariates as the main analysis, tract fixed effects, and time effects via ACS survey-year dummies, a regression of the number of restaurants on grocery stores yields a significant coefficient of 1.46. Standard errors are clustered by census tracts. This coefficient roughly means that an additional grocery store is associated with 1.46 additional restaurants in a census tract, thereby adding evidence showing that restaurants are more likely to locate near grocery stores.

There remains the question of why a restaurant would like to locate near a grocery store. An analysis of restaurant age sheds light on this question. The year a restaurant opens to the public is reported in ReferenceUSA. For restaurants that do not report this information, the year its YellowPages ad first appears approximates the year that the restaurant opens. Hence, the age of the restaurant is the difference between the survey year and the year of its opening. Because the last observable year in ReferenceUSA is 2018, there are now 3 newly constructed grocery stores and 3 renovation sites that open after 2018 constituting the control group. Column 1 of Table 3.5 compares restaurants within half a mile of a store that will eventually open to the public to restaurants within half a mile of a store that has yet to open to the public, similar in spirit to the store-proximity results, illustrated by Figure 3.10. A new store is then shown to increase the lifespan of a restaurant by a fifth of a year, or about 2.5 months. Upon including restaurants farther away from a new store (0.5 to 1 mile away) as part of the control group in Column 2 of Table 3.5, the data show a similar, albeit smaller, effect. Column 2 is the most conservative estimate, saying that restaurants near new stores survive about 2 months longer compared to restaurants farther away. Columns 3 and 4 attempt to replicate the effect for restaurants surrounding renovation sites, but the analysis fails to uncover an observable impact of renovations on age of restaurants. Like before, the distinction between the first two columns versus the latter two columns supports

Table 3.5: Age of Restaurants

VARIABLES	(1) New Constr. $0-0.5$ mi.	(2) New Constr. $0-1$ mi.	(3) Renovations $0-0.5$ mi.	(4) Renovations $0-1$ mi.
DD	0.2088**	0.1758**	-0.0155	-0.0167
	(0.0999)	(0.0830)	(0.0839)	(0.0543)
Observations	9,310	35,043	10,085	40,179
Store FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Notes: All dependent variables are age, in years, of restaurants. The sample contains restaurants within a certain distance of a FRESH store. A restaurant is considered treated if it is within 0.5 miles of FRESH store that has opened to the public. For Columns 1 and 3, there are three new construction sites and three renovation sites, respectively, that have yet to open to the public between 2005 to 2018, the observable years in ReferenceUSA. Those sites constitute their respective specification's control group. Columns 2 and 4 expand the control group to include restaurants that are half a mile to one mile away from the FRESH store. Similar to Table 3.4, significant effects are observed only near new construction sites. Restaurants near a new supermarket are estimated to survive for about 0.18 years (2.1 months) to 0.21 (2.5 months) longer relative to similar businesses farther away. Controls are omitted for brevity.

the notion that grocery stores enable restaurants to survive longer.

Upon looking at restaurant sales, it is clear why a restaurant near a new store would be able to survive longer. Table 3.6 conducts the same analysis but changes the dependent variable to the log of sales. Table 3.6 reports the results. Column 1 shows that a restaurant experiences a 9.1% increase in sales once a nearby grocery store opens to the public. Likewise, Column 2 shows that there is an increase of 12.2% in sales for restaurants near a new store relative to those farther away. Both estimated increases in sales account for size of the restaurant by controlling for number of employees, so these restaurants are possibly more profitable. While restaurants near renovation sites are not observed to survive longer, one possible reason could be a decrease in sales, as suggested by Column 3. Nevertheless, with restaurants experiencing greater profitability and surviving longer near a new grocery store,

Table 3.6: Sales in Restaurants

VARIABLES	(1) New Constr. $0-0.5$ mi.	(2) New Constr. $0-1$ mi.	(3) Renovations $0-0.5$ mi.	(4) Renovations $0-1$ mi.
DD	0.0909***	0.1220***	-0.0761**	0.0127
	(0.0320)	(0.0269)	(0.0320)	(0.0204)
Observations	9,308	34,993	10,075	40,131
Store FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Notes: All dependent variables are logged sales of restaurants. The sample contains restaurants within a certain distance of the FRESH store. A restaurant is considered treated if it is within 0.5 miles of FRESH store that has opened to the public. For Columns 1 and 3, there are three new construction sites and three renovation sites, respectively, that have yet to open to the public between 2005 and 2018, the observable years of ReferenceUSA. Those sites constitute their respective specification's control group. Columns 2 and 4 expand the control group to include restaurants that are half a mile to one mile away from the FRESH store. Similarly to Table 3.4, significant and positive effects are observed only near new construction sites, even after controlling for size of the restaurant through number of employees. Restaurants near a new supermarket are estimated to make an extra 9.1% to 12.2% in sales relative similar businesses farther away. Those that are near renovation sites seem to experience a decrease in sales, but statistical significance disappears after extending the control group to include restaurants further away from renovation sites. Controls are omitted for brevity.

there is evidence to support the claim made in *Going to Market*. Full-line food stores are high-value magnets that attract complementary stores and services, thereby indirectly increasing property values through an indirect improvement to local amenities.

3.6 Conclusion

FRESH provides financial and zoning incentives to encourage building and operating grocery stores in neighborhoods thought to lack access to fresh groceries. One stated justification for

FRESH is that it increases property values. This paper tests that claim by first establishing the program's intent-to-treat effect using changes in the program's geographic coverage over time. The estimate shows that the provision of incentives leads to an increase of 13.2% in sales prices of residential properties. Then to measure the impact of the actual opening of a grocery store on property values, sales near newly constructed stores are compared to sales farther away by focusing on openings at different times. The store-proximity results say that a newly constructed store adds 7.93% to a property's assessed value. This estimate impacts sales price insofar as buyers and sellers of real estate consider property assessments. It certainly impacts the city's tax revenues and the public services that rely on public funds.

The main driver behind an increase in property values is an improvement in local amenities. Not only are grocery stores inclined to locate within a FRESH area, but related retail such as restaurants are as well. Restaurants are inclined to locate in these areas because of potential profits. Restaurants near a newly constructed store experience an observable increase in sales relative to restaurants farther away. Indeed, an observable increase in restaurant sales supports the idea that restaurants survive longer near a FRESH store.

Potential future research in this area could include determining who benefits from the increase in property values and if so, by how much. It would also be prudent to see if these results hold in other cities with similar programs, such as Philadelphia's (eventually all of Pennsylvania) Fresh Food Financing Initiative. In 2010, the Obama administration introduced the Healthy Food Financing Initiative nationwide. These programs are opportunities to assess how food systems influence the urban landscape.

Bibliography

Abbott, W. F. (1982). The density-pathology hypothesis in comparative perspective: Density, status and pathology in prorevolutionary moscow. *International Journal of Comparative Sociology*, 23:17.

Allcott, H., Diamond, R., Dubé, J.-P., Handbury, J., Rahkovsky, I., and Schnell, M. (2019). Food deserts and the causes of nutritional inequality. *The Quarterly Journal of Economics*, 134(4):1793–1844.

Baker, J., Mann, R., and Cordero, R. (2018). Refresh: Assessing the zoning and financial incentives of the food retail expansion to support health program.

Bandiera, O., Barankay, I., and Rasul, I. (2005). Social preferences and the response to incentives: Evidence from personnel data. *The Quarterly Journal of Economics*, 120(3):917–962.

Bitler, M. and Haider, S. J. (2011). An economic view of food deserts in the united states. *Journal of Policy Analysis and Management*, 30(1):153–176.

Blake, K. S., Kellerson, R. L., Simic, A., and Task, E. (2007). Measuring overcrowding in housing. *US Department of Housing and Urban Development, Office of Policy Development and Research*.

Blomquist, G. and Worley, L. (1981). Hedonic prices, demands for urban housing amenities, and benefit estimates. *Journal of Urban Economics*, 9(2):212–221.

Brueckner, J. K., Thisse, J.-F., and Zenou, Y. (1999). Why is central paris rich and downtown detroit poor?: An amenity-based theory. *European economic review*, 43(1):91–107.

Burkus, D. (May 2017). Work friends make us more productive (except when they stress us out). Harvard Business Review. Retrieved from `https://hbr.org/2017/05/work-friends-make-us-more-productive-except-when-they-stress-us-out` [Accessed: 2019-01-31].

Burr, J. A. and Mutchler, J. E. (2012). Housing characteristics of older asian americans. *Journal of cross-cultural gerontology*, 27(3):217–237.

Burr, J. A., Mutchler, J. E., and Gerst, K. (2010). Patterns of residential crowding among hispanics in later life: Immigration, assimilation, and housing market factors. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 65(6):772–782.

Clarke, W. and Freedman, M. (2019). The rise and effects of homeowners associations. *Journal of Urban Economics*, 112:1–15.

Cohen, N. (2018). Refresh: Modifying the food retail expansion to support health program to improve healthy food access.

Cummins, S., Flint, E., and Matthews, S. A. (2014). New neighborhood grocery store increased awareness of food access but did not alter dietary habits or obesity. *Health affairs*, 33(2):283–291.

Currie, J. and Yelowitz, A. (2000). Are public housing projects good for kids? *Journal of public economics*, 75(1):99–124.

Ellen, I. G. (2020). What do we know about housing choice vouchers? *Regional Science and Urban Economics*, 80:103380.

Emeruwa, U. N., Ona, S., Shaman, J. L., Turitz, A., Wright, J. D., Gyamfi-Bannerman, C., and Melamed, A. (2020). Associations between built environment, neighborhood socioeconomic status, and sars-cov-2 infection among pregnant women in new york city. *Jama*, 324(4):390–392.

Eriksen, M. D. and Ross, A. (2013). The impact of housing vouchers on mobility and neighborhood attributes. *Real Estate Economics*, 41(2):255–277.

Eriksen, M. D. and Ross, A. (2015). Housing vouchers and the price of rental housing. *American Economic Journal: Economic Policy*, 7(3):154–76.

Evans, G. W. (2001). Environmental stress and health. *Handbook of Health Psychology*, pages 365–385.

Evans, G. W. (2006). Child development and the physical environment. *Annu. Rev. Psychol.*, 57:423–451.

Evans, G. W., Maxwell, L. E., and Hart, B. (1999). Parental language and verbal responsiveness to children in crowded homes. *Developmental psychology*, 35(4):1020.

Ferguson, K. T., Cassells, R. C., MacAllister, J. W., and Evans, G. W. (2013). The physical environment and child development: An international review. *International Journal of Psychology*, 48(4):437–468.

Glaeser, E. L., Kim, H., and Luca, M. (2018). Nowcasting gentrification: using yelp data to quantify neighborhood change. 108:77–82.

Goux, D. and Maurin, E. (2005). The effect of overcrowded housing on children's performance at school. *Journal of Public Economics*, 89(5-6):797–819.

Harsanyi, J. C., Selten, R., et al. (1988). A general theory of equilibrium selection in games. *MIT Press Books*, 1.

Hendrickson, D., Smith, C., and Eikenberry, N. (2006). Fruit and vegetable access in four low-income food deserts communities in minnesota. *Agriculture and Human Values*, 23(3):371–383.

Holmstrom, B. (1982). Moral hazard in teams. *The Bell Journal of Economics*, pages 324–340.

Horn, K. M., Ellen, I. G., and Schwartz, A. E. (2014). Do housing choice voucher holders live near good schools? *Journal of Housing Economics*, 23:28–40.

Jiao, J., Moudon, A. V., and Drewnowski, A. (2011). Grocery shopping: how individuals and built environments influence choice of travel mode. *Transportation research record*, 2230(1):85–95.

Kandel, E. and Lazear, E. P. (1992). Peer pressure and partnerships. *Journal of political Economy*, 100(4):801–817.

Katz, L. F., Kling, J. R., and Liebman, J. B. (2001). Moving to opportunity in boston: Early results of a randomized mobility experiment. *The Quarterly Journal of Economics*, 116(2):607–654.

Kennedy, L. W., Caplan, J. M., Piza, E. L., and Buccine-Schraeder, H. (2016). Vulnerability and exposure to crime: Applying risk terrain modeling to the study of assault in chicago. *Applied Spatial Analysis and Policy*, 9(4):529–548.

Kling, J. R., Liebman, J. B., and Katz, L. F. (2007). Experimental analysis of neighborhood effects. *Econometrica*, 75(1):83–119.

Lepore, S. J., Evans, G. W., and Palsane, M. (1991). Social hassles and psychological health in the context of chronic crowding. *Journal of Health and Social Behavior*, pages 357–367.

Logan, J. R., Xu, Z., and Stults, B. J. (2014). Interpolating us decennial census tract data from as early as 1970 to 2010: A longitudinal tract database. *The Professional Geographer*, 66(3):412–420.

Marschak, J. and Radner, R. (1972). *Economic Theory of Teams.*

Martin, K. S., Ghosh, D., Page, M., Wolff, M., McMinimee, K., and Zhang, M. (2014). What role do local grocery stores play in urban food environments? a case study of hartford-connecticut. *PloS one*, 9(4):e94033.

Mas, A. and Moretti, E. (2009). Peers at work. *American Economic Review*, 99(1):112–45.

Merriam, D., Bality, A., Stein, J., and Boehmer, T. (2017). Improving public health through public parks and trails: Eight common measures. summary report.

Mills, G., Gubits, D., Orr, L., Long, D., Feins, J., Kaul, B., Wood, M., Jones, A., et al. (2006). Effects of housing vouchers on welfare families. *Washington, DC: US Department of Housing and Urban Development, Office of Policy Development and Research. Retrieved October*, 8:2010.

Myers, D., Baer, W. C., and Choi, S.-Y. (1996). The changing problem of overcrowded housing. *Journal of the American Planning Association*, 62(1):66–84.

Olsen, E. O. (2003). Housing programs for low-income households. *Means-tested transfer programs in the United States*, pages 365–442.

Rickard, B. J., Costanigro, M., and Garg, T. (2013). Economic and social implications of regulating alcohol availability in grocery stores. *Applied Economic Perspectives and Policy*, 35(4):613–633.

Rosen, S. (1974). Hedonic prices and implicit markets: product differentiation in pure competition. *Journal of political economy*, 82(1):34–55.

Saiz, A. (2010). The geographic determinants of housing supply. *The Quarterly Journal of Economics*, 125(3):1253–1296.

Seppälä, E. and Cameron, K. (December 2015). Proof that positive work cultures are more productive. Harvard Business Review. Retrieved from `https://hbr.org/2015/12/proof-that-positive-work-cultures-are-more-productive` [Accessed: 2019-01-31].

Sinai, T. and Waldfogel, J. (2005). Do low-income housing subsidies increase the occupied housing stock? *Journal of Public Economics*, 89(11-12):2137–2164.

Smith, J. (September 2013). How much coworker socializing is good for your career? Forbes Magazine. Retrieved from `https://www.forbes.com/sites/jacquelynsmith/2013/09/24/how-much-coworker-socializing-is-good-for-your-career/#d50344151a06` [Accessed: 2019-01-26].

Smith, L., Goranson, C., Bryon, J., Kerker, B., and Nonas, C. (2011). Developing a supermarket need index. *Geospatial analysis of environmental health*, pages 205–221.

Susin, S. (2002). Rent vouchers and the price of low-income housing. *Journal of Public Economics*, 83(1):109–152.

Teller, C., Holweg, C., Reiner, G., and Kotzab, H. (2018). Retail store operations and food waste. *Journal of Cleaner Production*, 185:981–997.

Varady, D. P. and Walker, C. C. (2003). Housing vouchers and residential mobility. *Journal of Planning literature*, 18(1):17–30.

Vildosola, D., Carter, J., Louderback, E. R., and Roy, S. S. (2020). Crime in an affluent city: Applications of risk terrain modeling for residential and vehicle burglary in coral gables, florida, 2004–2016. *Applied Spatial Analysis and Policy*, 13(2):441–459.

Walk-Morris, T. (2021). How adaptive reuse can help solve the housing crisis. *American Planning Association*.

Wright, C. (May 2017). 10 things to know about google's awesome culture. Huffington Post. Retrieved from `https://www.huffingtonpost.com/entry/10-things-to-know-about-googles-awesome-culture_us_59088802e4b03b105b44bbfd` [Accessed: 2019-01-31].

Yinger, J. (2015). Hedonic markets and sorting equilibria: Bid-function envelopes for public services and neighborhood amenities. *Journal of Urban Economics*, 86:9–25.