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Staples in the Community: A Trust Game Approach for Establishing Grocery Stores in Underserved Areas

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Abstract

Despite millions of dollars being invested in establishing grocery stores in underserved areas, we still find these stores fail in the long run. To address this, we created a game theoretical model that incorporates residential trust as a factor in evaluating grocery store success. Our theoretical results show that residents with low or no trust are less likely to frequent a new grocery store, even with discounted prices or lower travel costs. Using a case study, we further show how insight from our game theory model can be used to design place-specific successful food access policies. (*JEL* I38, C70, D11)

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Introduction

Since the 2014 farm bill, over $1.3 billion dollars in Healthy Food Financing Initiative (HFFI) federal grants have been used to leverage additional support in financing the opening of over one thousand grocery stores in underserved US neighborhoods in 48 states (National Sustainable Agriculture Coalition, 2023). Grocery stores are often considered a staple for a local economy due to being a consistent source of healthy foods for a community. Communities that lack grocery stores may suffer from food insecurity or obesity-related issues. While food initiatives such as HFFI grants aid in eliminating supply-side issues for targeted underserved locations, they do not guarantee success for local grocery stores.

For example, in 2023, a Piggly Wiggly in Spartanburg, SC, announced it was shutting down due to lack of demand and low grocery sales (Swann, 2023). This store closure was impactful for three reasons. First, it was the closest grocery store for the southside community, an area that suffers from low food access. Secondly, stakeholders, including the local government and private foundations, had invested $900,000 to make sure the new store would open in this underserved community. Despite this investment, the store still had an unsuccessful outcome and did not last long in the community, staying open only a little over a year. Importantly, this is not a rare case of local grocery store failure in a community. It is easy to find news stories or articles about stores in neighborhoods without many other options closing due to financial underperformance or high rates of theft (Engler Stringer et al., 2019; Loeb, 2023; Tobin, Reuter, and Dean, 2023).

Cases such as these make clear work remains in finding the best policies to address food access. In efforts to understand low income residents' demand for local food access, studies show that residents typically do not purchase groceries at their nearest grocery store and travel farther to their usual grocery store (Allcott, 2019; Morrison and Mancino, 2015). A minimally examined factor that may affect the resident's demand for a new, local grocery store is trust in the store.

In this paper, we seek to highlight residential trust as a feature that can affect the success of opening a grocery store in a low-food access area. Trust can be defined as a positive expectation of other players' actions in a mutually beneficial agreement within an uncertain environment (Bhattacharya et al., 1998, Ederer and Schneider, 2022). We create a variation of the Trust Game focused on opening a subsidized grocery store. Berg et al., (1995) designed a game theoretic model that rationalized how trust can impact consumers' economic choices and payoffs. The game has been applied in many areas, including bargaining, competition, discrimination, and marriage, and has shown that trust plays a crucial factor in decisions (Bartling et al., 2009; Castilla, 2015; Croson and Buchan, 1999; Hargreaves et al. 2009). Given that residents' trust is unknown to many store operators when they open a store, we crafted a Bayesian game theoretic model with incomplete information that embeds residents' trust in government and store operators' decisions to open and maintain a grocery store in a low-food access area.

Essentially, our Local Food Access (LFA) Trust Game model showcases the relationship between a new local grocery store and their targeted community. Numerous papers have analyzed the effectiveness of incentivizing grocery chains to open stores in underserved locations on reducing food insecurity and improving food access; however, results show mixed success (Beaulac et al., 2009; Brinkley et al., 2019; Dubowitz et al., 2015; Cantor, et al., 2020; Ghosh-Dastidar et al., 2017). Our model takes this a step further and highlights the effectiveness of various food initiative policies from the lens of residential trust. Our objective is to create a model that captures what occurs in reality and provide potential avenues for policymakers to better design place-specific food initiatives in ways that increase the odds that opening an incentivized store will actually lead to improved food access and increased healthy food purchases.

This paper is structured as follows. First, we detail our game theoretical model for predicting grocery store success across a diffuse trust prior distribution. The model incorporates trust, prices, travel and adjustment costs, the option of employing an influencer who has trust within a given community, and the cost of maintaining the upkeep of the store. Secondly, we present a case study in the form of a small scale exercise of our theoretical model to provide place-specific understanding for policymakers. We use a consumer survey to derive respondents' perceived trust within the LA metro area, build an informative prior for the Trust Game, and show how outcomes vary over space. Lastly, we discuss the real-world policy implications of this research and how it informs policies targeting food access-related issues.

Intuitively, our results make sense: residents respond to price discounts, and communities with high trust are more likely to adopt a new grocery store as their primary location for purchasing healthy food such as fruits and vegetables, while residents with low or no trust are less likely to frequent the store even with discounted prices or lower travel costs. We highlight that new local grocery stores may have to compete against the residents' trust in their usual grocery store. Despite paying a higher travel cost, residents may have established a trusted routine with their usual grocery store and may be accustomed to the store's layout or have brand familiarity with their grocery items. New local grocery stores also may have to overcome the residents' inherited distrust of a previous grocery store at their location. Ultimately, these hurdles can be too high, and residents may not switch to frequenting the new store. Our application results find that even within the LA Metro, trust levels vary significantly enough that policy choices should vary across neighborhoods just a few miles apart. This demonstrates how place-specific variations in trust can produce different recommended policies.

The findings from this paper contribute to the literature that has analyzed the effectiveness of incentivizing grocery chains to open stores in underserved locations suffering from food insecurity and food deserts (Beaulac et al., 2009; Brinkley et al., 2019; Dubowitz et al., 2015; Cantor et al., 2020; Ghosh-Dastidar et al., 2017). We examine the importance of trust as an underutilized policy lever for addressing the food insecurity and low food access problem affecting millions of U.S. households: trust. In so doing, we also contribute to the broader literature on the role of trust in decision-making and achieving high-value outcomes (Ederer, 2022; Bohnet et al., 2008). We also add another study to the set of work employing versions of Trust Games to study and provide insight into a wide array of economic situations (Bartling et al., 2009; Castilla, 2015; Croson and Buchan, 1999; Hargreaves et al., 2009).

Theoretical Framework

Structure of the Trust Game

The Local Food Access (LFA) Trust Game is a non-cooperative game theoretic model that evaluates the optimal choices and combinations for opening (and possibly closing) a grocery store in a low food access area. **Figure 1** shows the structure of the LFA Trust Game. The game has two players: Stakeholders and Residents. The Stakeholders represent a partnership between the government and the grocery store operator to open a subsidized grocery store in a low food access area. The Residents represent a low food access community where the grocery store will open. The Stakeholders act as the leading player, and the Residents act as the follower player. The game starts with the Stakeholders agreeing to sign a multi-year lease to open a grocery store close to the Residents' area and proceeds as follows. The Stakeholders move first and must decide whether or not to involve an influencer, who serves as an icon in the Residents' area, in endorsing the new store's opening. Once decided upon, the grocery store will open. The Residents will react to the store and determine whether they want to adopt it as their primary grocery store. If the Residents adopt the grocery store as their primary store, they will frequent the new store more than their previously preferred grocery store. If they do not adopt the grocery store as their primary store, they will continue frequenting their preferred grocery store and occasionally frequent the Stakeholder's store because it is convenient. The Stakeholders then make the final move and evaluate the store. Depending on the store's profits, they have three options: renew the store lease and maintain the store upkeep, renew the store lease but do not maintain store upkeep, or close the store.

Figure 1: Structure of the LFA Trust Game

While the structure of the game is sequential, the entire game is played in normal form, where each player moves simultaneously. This was done to keep the game static and reflect all possible outcomes of the game's structure. The entire duration of the normal form game is the term of the store lease. Lastly, each player has two types that operate under different motivations and have different payoffs.

The Stakeholder's types vary on prices for healthy foods and the Residents' types vary on trust. Because each player has two types, there are four Trust Games encompassing each combination of types of Stakeholders and Residents. While Trust Games under complete information assume that each player knows the other types, this may not occur in reality.

Bayesian LFA Trust Games

Typically for Bayesian games with incomplete information, each player has two types and one or both players can be uncertain of the other's type which can directly affect the payoffs (Harsanyi, 1995; Huang, 2011; Wiggers et al., 2015; Zamir, 2020). The types are not known prior to the game but signals can be shown during the game.

Suppose, Residents and Stakeholders know their respective type but the Stakeholders have uncertainty on the Residents' type. This is the premise for a Bayesian variation of the Trust Games under the assumption of one-sided incomplete information. In this case there are only two Trust Games, one for each type of Stakeholders. We chose to focus solely on the Stakeholders with incomplete information because it is more difficult for the Stakeholders to know whether Residents trust them than for Residents to know whether a store is offering discounted or normally priced healthy foods.

Prices for Trust Games

One major assumption of our research is that we cannot assume Residents only focus on retail prices for foods. There are other factors including transportation cost. For simplicity, a Hotelling model was also used to provide insight into relative profits for the firm based on location. Alternatively, the Salop circular city model could be used to measure product differentiation by location distances (Salop and Stiglitz, 1977). The Hoteling model measures firm prices based on the travel distance two or more firms are from their consumers (Graitson, 1982). This model has major implications regarding the low food access problem because it includes travel costs as an added cost associated with the price of a good in a store. Gicheva et al. (2010) found that rising gas prices lead to lower profit margins for grocery stores because consumers must include travel costs when deciding if they should frequent the store. **Figure 2a** shows a traditional Hotelling model diagram from the LFA Trust Game perspective, where the y-axis is prices for healthy food and travel costs, and the x-axis is distance. 0 represents the Stakeholders' store location, and 1 is the Residents' usually frequented grocery store location.

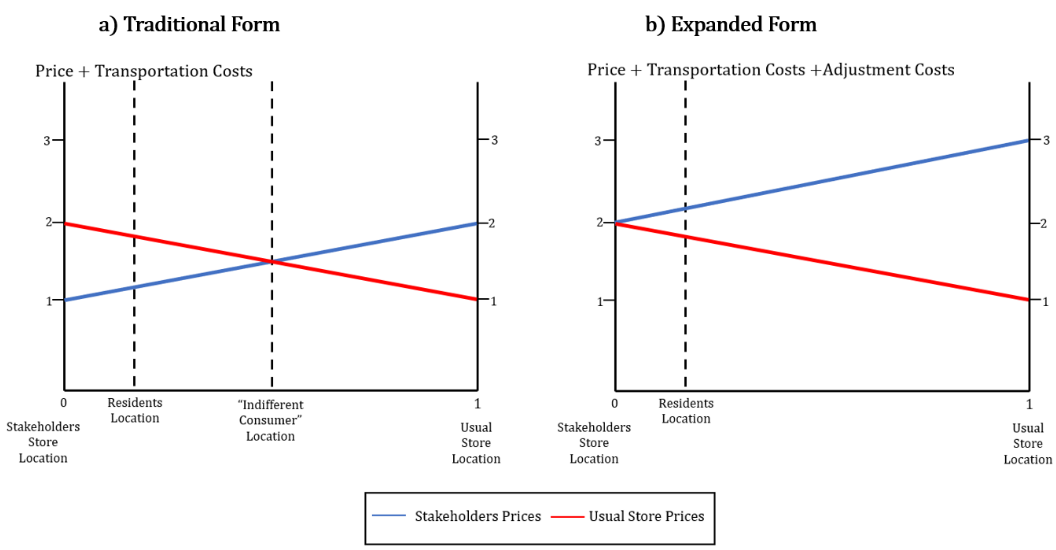

Figure 2: Hotelling Model Diagram

Typically, the Hotelling model shows the location for an "Indifferent Consumer." The middle-dashed line of **Figure 2a** represents the location where a consumer is equally well-off shopping at either store. In this case, the Residents would be better off shopping at the Stakeholders' grocery store than their usual store. The Residents prefer the Stakeholders' store's prices because when you include travel costs, they are lower than the price they would pay at their usual grocery store.

Now, suppose we expand on the basic Hoteling model and include the cost of preferences, trust, and inconvenience. Morrison and Mancino (2015) report that SNAP participants, on average, live 1.96 miles from the nearest grocery store but travel 3.36 miles to their usual grocery store. This implies that Residents include more than travel costs in their decisions to adopt a grocery store as their primary store. We can assume there is an adjustment cost or cost of inconvenience also included in the prices of foods. Suppose a new grocery store is built near the Residents. In that case, they might incur an adjustment cost if they adopt the new store, which can include adjusting to the new store's layout and possibly distrust from past experiences at that location. In this case, suppose the Residents incur a cost of $1.00 upon adopting the new store (from some combination of lack of trust and adjusting to a different store). Now, the diagram changes. **Figure 2b** shows a diagram including a high adjustment cost on the Stakeholders' store. In this case, the total price for shopping at the older store is lower than the Stakeholders' store despite the minor travel cost to the closer store location. Also, notice that there is no longer an indifferent consumer because regardless of distance, the usual store is preferred to the Stakeholders' store because the total net cost at the usual store is lower for the consumer.

Another factor that is important is food initiatives that offer price discounts on healthy foods. **Figure 3** shows the Trust Game Hotelling model used to motivate the full economic cost Residents face from different types of Stakeholders compared to their usual store. In this case, the common retail price for healthy foods is normalized to equal $1.00 but one type of Stakeholders offers a discounted price for healthy foods of $0.50. The blue line represents the normal prices for the proposed store, the green line represents the discounted prices for the store, and the red line represents the prices for the other store. Similar to the original model, the Residents prefer the local store over their usual store if only travel costs are taken into account (**Figure 3a**) but this changes when adjustment costs are added (in

Figure 3b). Now the normal store's price is higher than the usual store price, and the discounted store's price is still lower. Thus, whether Residents will frequent the proposed store depends on the level of adjustment costs anticipated. Also, when adjustment costs are included, there is no longer an indifferent consumer for the normally priced store and the usual store because prices for the normal store are too high but there are still customers indifferent between the discount-price store and their usual store.

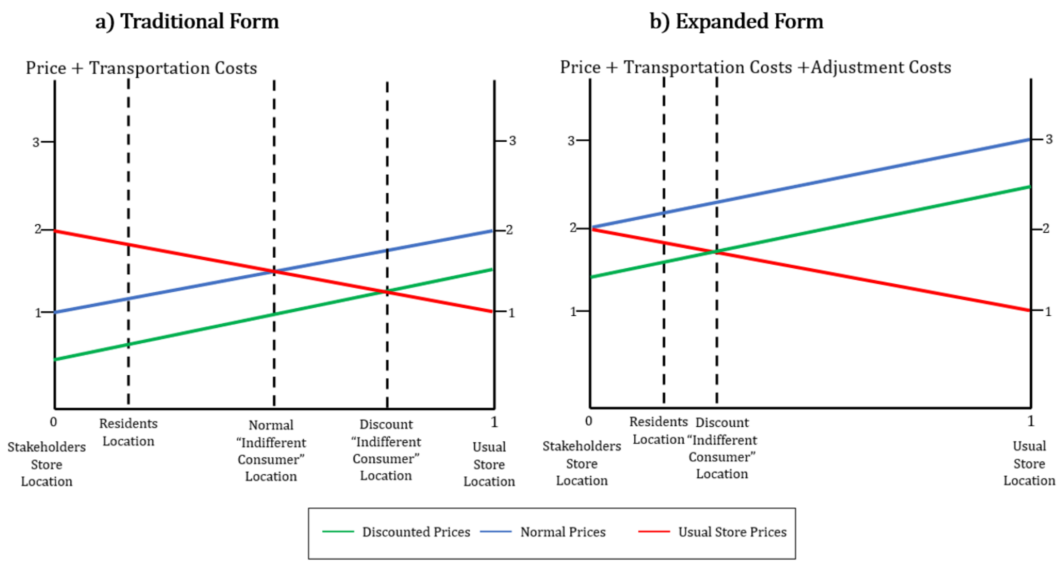

Figure 3: Hotelling Model for Bayesian Trust Games

Players

i. The Stakeholders

The Stakeholders' payoffs are calculated based on profitability in dollars (π). The profitability of a grocery store in a low food access area is a major concern that requires developing cost-effective strategies that analyze the tradeoffs of demand-stimulating policies and supply-side policies (Cleary et al., 2018). Coibion et al. (2018) provide evidence that when firms such as grocery stores are given new information on the economy, they process it and update their beliefs in a Bayesian way to maximize their profits. Grocery stores that cannot sustain profits are more likely to close and create a food desert environment. Alternatively, because grocery stores are primarily focused on profitability, they may have an incentive to gradually stop maintaining the upkeep of the store to save money, producing a higher profit, at least in the short run. This can be deemed a form of persuasion because they cater to households that live in a food desert and believe they have market power and can cut costs while maintaining retail prices (Kamenica and Gentzkow, 2011; Bitler and Haider, 2011).

For estimating the Stakeholders' payoffs for the game, we consulted a grocery store operator to aid in estimating the costs of opening and maintaining a grocery store. Rent and occupancy costs typically are 3.5%-4.5% of gross sales. Grocery stores usually operate at least until their lease ends. They typically do not go over a five-year renewal on a lease unless it is a new building on which the lease could last 20 years. If the grocery store is closing, it will likely correspond with the end of the lease term. Regarding maintaining store upkeep, grocery stores have two options: refreshing and remodeling the store. A refresh increases gross sales by 10% and costs 2% of gross sales. Remodeling the store increases gross sales by 15%-20% and costs roughly 20% in gross sales.

For the Bayesian variations of the Trust Game, there are two types of Stakeholders that differ based on their prices offered for healthy foods: discounted prices (D-Price) and normal prices (N-Price). The D-Price Stakeholders' store offers an immediate 50% discount on healthy foods funded by a program from the government, whereas the N-Price Stakeholders' store is not funded by the program. Funding from the D-Price program is very competitive and only lasts a set number of years. For further context, the D-Price Stakeholder's program is based on actual government policy embodied in the Gus Schumacher Nutrition Incentive Grant

Program (GusNIP), which is further elaborated on in the policy implications and discussion section below.

For simplicity, the N-Price Stakeholders' store can be viewed as the more traditional attempt of improving food access in an area by procuring grants or loans for overcoming the high initial entry cost for placement in an underserved community. The D-Price Stakeholders' store is the less common solution to these problems, by improving food access and providing healthy food at a price discount to encourage healthy eating. Both types of Stakeholders make the same two overall decisions in the game.

ii. The Influencer

The Influencer represents an optional partner included in the Stakeholders agreement. They are the first choice the Stakeholders make in the game. The Influencer can compensate for distrust the Residents may have towards the stakeholders by endorsing the new store. There is an added cost for involving an Influencer, which can range from one-off payment to a social media influencer for advertising or funding events hosted by an influential person in the community to engaging in the community. According to signal theory, when an influencer or celebrity promotes a product or event, they differentiate it from similar products (Hoffman and Tan, 2015). Dimitrieska and Eframova (2021) found that businesses that engage in long run relationships with influencers, compared to one-off campaigns, increase the credibility of the business's product or brand.

Pei and Mayzlin (2020) create a game that focuses on including an influencer in marketing a product and find that including an influencer can benefit the firm by raising awareness for a product and increasing the probability of positive reviews but outcomes depend on the costs and consumers' prior beliefs. Hiring an influencer to market or endorse a product is common; in the fast food industry examples include the McDonald's Travis Scott Meal and Saweetie Meal, Burger King's Nelly Meal, and KFC's Jack Harlow Meal. Singer and Hidayat

(2021) focus on McDonald's partnership with Korean boy band BTS to create the BTS Meal in Indonesia and find that "preference and role models influenced the buying behavior; however, these factors influenced social empathy only when mediated by consumption."

iii. The Residents

The Residents' payoffs are in terms of utility and based on the model of Polisson et al. (2020) that evaluates expected utility from a choice over risk and uncertainty. We base the store utility functions used in the game on a theoretical model of consumer decision making in food desert regions from Hebda and Wagner (2016). Residents' payoffs are derived from utility functions for food purchases divided into relatively healthy (X_H) and unhealthy (X_U) foods at a grocery store. The prices at store *i* of each type of foods (P_{Hi} for healthy, and P_{Ui} for unhealthy) are based on the Hotelling model prices which includes their retail prices (P_R) and a convenience costs (C_{Ci}). The price of healthy foods can be shown below,

$$P_{Hi} = P_{Ri} + C_{Ci}. \tag{1}$$

The convenience costs include the transportation cost (T_{Ci}) and an adjustment cost (A_{Ci}) as explained in the Expanded Hotelling model. The convenience costs can be shown as

$$C_{Ci} = T_{Ci} + A_{Ci}. \tag{2}$$

We expand on the Hebda and Wagner model by considering that Residents' past experiences with that location or the Residents' utility from their previously frequented grocery store could affect whether they would frequent the proposed new grocery store. We add a store trust score (*STS*) to our utility function, which is the sum of a store's reputation score (Rep_i) and an influencer's impact score denoted as

$$STS_i = Rep_i + Influencer\ Score. \tag{3}$$

Each store (denoted by *i*) has a reputation score that includes demand factors such as the previous history of the store's location (the store turnover rate), quality of food at the store, and quality of the store (cleanliness, up-to-date technology). The reputation score is measured from 0 to 1, with a store reputation score of 1 being very favorable and 0 being unfavorable. The influencer's impact score measures how impactful the influencer is to the Residents. It can be derived from multiple factors including the number of followers on social media, if they produce high-quality content, and engagement with their followers and fans (Dimitrieska and Eframova, 2021). The score can be scaled and bounded between 0 and 1. This was done to showcase that a low store reputation score can be compensated for with a high influencer impact score. The influencer impact score is only applicable if the Stakeholders opt to hire an influencer.

We chose the Cobb Douglas as the utility function because it satisfies the conditions for the Hebda and Wagner model and allows simple solution for the output share of each good. We maximized the utility function subject to a budget constraint that includes M_i for the Residents' average income spent at each store and the respective prices for each category of food: P_{Hi} and P_{Ui}. The Residents' maximized utility for each grocery store they frequent based on income, prices and the *STS* can be written as:

$$U_i(X_H, X_U|STS) = STS_i((\frac{\alpha M_i}{P_{Hi}})^{\alpha}(\frac{(1-\alpha)M_i}{P_{Ui}})^{1-\alpha}). \tag{4}$$

This shows how the store trust score, *STS,* and the adjustment costs within the total perceived prices for healthy foods impact the Residents' utility, meaning Residents gain more utility from a grocery store that they have a high trust in or have to adjust minimally to in order to purchase their preferred groceries.

Highlighted by our expanded Hoteling model, we do not assume Residents will frequent the newly proposed grocery store just because they live in a low food access area. Before a new grocery store was placed in their community, Residents frequented another grocery store that might be farther away to purchase their groceries; that grocery store already has the Residents' trust, and the Residents gain utility from that store. If a new grocery store opens, it has to compete with the previous store and contend with the history of the new location. If the new grocery store opens at a location with a history of stores not lasting long, Residents will not believe the new store will last and will not adopt it as their primary store.

Realistically, Residents can visit and purchase groceries from multiple grocery stores and they can have different trust levels for each store. Because we are comparing the utility the Residents gain from multiple stores to the proposed store, we utilize the framework of Polisson et al. (2020) that analyzes the expected utility of a preferred option over various other options to create the Residents payoff utility function. We create a frequency share ($Freq_i$) that weights the Residents' utility from a store by the relative frequency of shopping at each store depending on whether they adopt the new store as their primary grocery store and if the store is maintained, not maintained, or closed. It measures the number of visits Residents made to the store (v_i) divided by the total number visits they made to all stores in a given period (V) as expressed below

$$Freq_i = \frac{v_i}{V}. \tag{5}$$

The frequency share is bounded and must sum to one across all stores. Because the frequency shares must sum to one, the Residents' utility payoff (Φ) is the sum of each store's utility weighted by the individual frequency shares:

$$\Phi = \sum_{i=1}^{I} Freq_i U_i(X_{Hi}, X_{Ui}|STS_i) \quad s.t \sum_{i=1}^{I} Freq_i = 1. \tag{6}$$

For simplicity in the Trust Games, we will focus on only two stores: the Stakeholders store (*SS*) and the Residents usually frequented grocery store (*US*). The Residents payoff for the Trust Game can be written in terms of the proposed store's frequency share as:

$$\Phi = Freq_{SS}U_{SS} + (1 - Freq_{SS})U_{US}. \quad (7)$$

For the Bayesian Trust Games, the Residents' two types are Trust and No Trust. These two types differ based on their reputation score for the proposed store. The Trust type will have a higher reputation score for the proposed store than the No Trust type. The rationale for the difference in type, is that the Trust type will always be more likely to adopt the proposed store than the No Trust type.

Lastly, it is important to note that while trust is exogenously expressed in our model through the Store Trust Score and reputation score, it is endogenous in nature to residents. To capture this, our results can be viewed through the lens of shadow prices that incorporate trust. The adjustment cost can be viewed as containing a reputation score minus an added benefit (the influencer score). This can be interpreted as the intrinsic cost (or value) of trust. For example, calculated in our model, Residents that trust the Stakeholder view the price for heathy foods as $1.00 while Residents that do not trust the Stakeholders would view that price as $6.25 due to the intrinsic cost of (the lack of) trust. More information on trust-incorporating shadow prices can be found in **Appendix A**.

Trust Game Form

The Trust Game is played in normal form as shown in **Table 1**. The payoffs for the Stakeholders are in terms of profit in thousands of dollars at the end of the lease period and the Residents' payoffs are in terms of Residents' utility. An outcome of the game is any Nash equilibria which is defined as the best action of a player given the other player's best action. A Bayesian Nash equilibrium will be defined as the best response for each type of Stakeholders and Residents given their beliefs about the state of the other player. For our Bayesian Trust Games, we refer to each complete information Trust Games as scenarios because they show the strategies and payoffs of each type combination of Stakeholders and Residents.

Table 1: Normal Form of the Trust Game

Residents	Stakeholders: *IM*	*ID*	*IC*	*NM*	*ND*	*NC*
A	$(\Phi_{1,1}, \pi_{1,1})$	$(\Phi_{1,2}, \pi_{1,2})$	$((\Phi_{1,3}-\varepsilon), \pi_{1,3})$	$(\Phi_{1,4}, \pi_{1,4})$	$(\Phi_{1,5}, \pi_{1,5})$	$((\Phi_{1,6}-\varepsilon), \pi_{1,6})$
DA	$(\Phi_{2,1}, \pi_{2,1})$	$(\Phi_{2,2}, \pi_{2,2})$	$(\Phi_{2,3}, \pi_{2,3})$	$(\Phi_{2,4}, \pi_{2,4})$	$(\Phi_{2,5}, \pi_{2,5})$	$(\Phi_{2,6}, \pi_{2,6})$

Note: For the Stakeholders, an "*I*" represents hiring an influencer, and "*N*" represents not hiring an influencer. An "*M*" represents renew the store lease and maintain store upkeep, "*D*" represents renew the store lease but do not maintain store upkeep, and "*C*" stands for close the store. For the Residents, an "*A*" represents adopting the store as their primary grocery store, and "*DA*" represents don't adopt the store as their primary grocery store. The entire duration of the normal form game is the term of the store lease.

The differences in the Residents payoffs are based on the Stakeholders' choices and are reflected in changes in the Residents' frequency shares of the proposed store as a frequency share hierarchy,

$$Freq_{PS}^{M} > Freq_{PS}^{D} > Freq_{PS}^{C} \quad (8)$$

where frequency shares are ordered such that maintained stores always have the highest frequency and closed stores the lowest frequency, regardless of type and if an influencer is hired. This was done to show Residents will frequent a maintained store over a non-maintained store and they cannot frequent a closed store. Also, if the Residents chose to adopt the store and it closes, they will have a betrayal penalty (ε) included in their payoff function associated with the lost trust and adjustment costs of returning to shopping at their old store. This penalty equals the reputation score plus, if applicable, the influencer score.

Results of Theoretical Trust Game Outcomes

Baseline for Theoretical Results

For simplicity, we applied baseline values to the Trust Game to produce Nash equilibria. Robustness checks were done to verify the consistency of the values and are briefly summarized in **Appendix B**. For the theoretical Bayesian variations of the game, we estimate the models under a diffuse or uninformative prior distribution. This means any prior beliefs the players may have can occur and there is no information regarding the likelihood of any specific prior belief occurring. All theoretical results were created and calculated using R.

For the Residents payoffs, we assume there are only two stores: the proposed grocery store and the Residents' previously frequented primary store. The price for healthy food from the N-Price type store was normalized to $1.00. The price for healthy food from the D-Price type store was set to $0.50 to reflect a 50% price discount. For the usual store, prices include an additional $1.00 travel costs which set the price for healthy foods to $2.00, and the price of unhealthy foods to $1.60. Because the previously frequented store is farther away from the Residents than the proposed store, the price of healthy food at the previously frequented store must be greater than the price at new stores operated by N-Price type Stakeholders. The Cobb Douglas weights are 0.5 denoting equal budget shares for unhealthy and healthy foods. The reputation score assigned by Trust type Residents is set to 1 and the reputation score awarded by No Trust type Residents is set to 0.4. The influencer score was normalized and set to 1.

We used our frequency share hierarchy to craft baseline shares for the games regardless of type and if an influencer is hired. If the Stakeholders maintain the store upkeep, we assign frequency shares of 1, and 0.3 for whether Residents adopt or don't adopt the store, respectively. This means if the Stakeholders choose to renew the lease and maintain the store, Residents will receive 100% of their utility from the proposed store if they adopt it, and 30% of their utility from the proposed store if they don't. The remainder of the frequency shares belong to the utility from their usual store. If the Stakeholders do not maintain the store upkeep, we assign frequency shares of 0.6 and 0.1 for when Residents adopt the store or don't adopt the store, respectively. If the grocery store closes, the Residents will receive 0 utility from the proposed store regardless of their choice because they no longer have the option to frequent the store. Note that if the Residents choose to adopt the store, they will have a betrayal penalty of ε subtracted from their payoff function that equals the reputation score plus, if applicable, the influencer score.

Interpreting Nash Equilibria

Throughout the Bayesian Trust Games, numerous Nash equilibria will arise showcasing an optimal outcome given the combination and choices of each player at a specific trust prior belief. All Nash equilibria will lead to an outcome that can be interpreted to various degrees as a positive outcome or negative outcome for the players. To simplify the interpretation, we grouped the Nash equilibria into three possible Trust Game outcome categories. Successful outcomes are all equilibria where Residents adopted the store as their primary grocery store and the Stakeholders renewed the store's lease and maintained the store's upkeep. Sustainable outcomes are all those where the Stakeholders renewed the store's lease but did not maintain the store's upkeep. Lastly, unsuccessful outcomes are all equilibria in which Residents did not adopt the store, the Stakeholders did not renew the lease, and the store closes.

These Trust Game outcomes primarily correspond with the Stakeholders' evaluation decision after the Residents move. The successful outcomes, corresponding with the store remaining opening and a well-maintained, quality store, is the ideal outcome. A sustainable outcome can be viewed as placing a mediocre grocery store in a low food access area to improve their food accessibility but not their food security. An unsuccessful outcome is one in which the store failed in the community.

LFA Trust Game Outcomes under Complete Information

Using the baseline values, we solved the four Trust Games scenarios under complete information as shown in **Figure 4**. We find scenarios with No Trust type Residents have multiple Nash equilibria, where at least one leads to a positive store outcome and one to an unsuccessful outcome. Both No Trust scenarios show the same unsuccessful outcome of $(\mathrm{DA}, \mathrm{NC})$ where the Residents do not adopt the store, the Stakeholders do not hire an influencer, will not renew the lease, and close the store. This outcome makes sense because when the Residents do not adopt the store, the Stakeholders do not make a profit and will be performing at a loss. The positive Nash equilibria varies based on the scenario and can be classified as successful or sustainable.

The Nash equilibria $(\mathrm{A}, \mathrm{IM})$ shows hiring an influencer is only optimal if the Residents are type No Trust, regardless of Stakeholders' type. This optimal outcome makes sense because if the Residents do not trust the Stakeholders, the influencer is needed to compensate for the lack of trust and the store must be maintained for the same reason. $(\mathrm{A}, \mathrm{ND})$ is the only sustainable outcome that occurs if the Stakeholders are type N-Price, and the Residents are type Trust. The Residents adopt the store and the Stakeholders do not hire an influencer, renew the lease, but don't maintain the store upkeep. Thie intuition behind this outcome is the Residents trust that the store will last and will frequent the store more, so an influencer is not needed. Also, the Stakeholders receive a higher profit by not maintaining the store upkeep and Residents will still frequent the store.

LFA Trust Game Outcomes under One-Sided Incomplete Information

Using an uninformative prior, the outcomes for the games can be interpreted as Bayesian Nash equilibria, where the optimal action for the Stakeholders depends

Figure 4: Normal Form Trust Game Scenarios

N-Price Type Stakeholders

β

Scenario: Trust / N-Price

	IM	ID	IC	NM	ND	NC
A	12.91, 10	8.86, 12	0.80, -1	6.45, 12	**4.99, 15**	1.80, 0
DA	5.83, -8	3.81, 0	2.80, -1	3.89, -6	3.16, 6	2.80, 0

(1- β)

Scenario: No Trust / N-Price

	IM	ID	IC	NM	ND	NC
A	**9.04, 6**	6.54, 3	1.40, -1	2.58, -2	2.67, 0	2.40, 0
DA	4.67, -10	3.42, -5	2.80, -1	2.73, -8	2.77, -3	**2.80, 0**

D-Price Type Stakeholders

β

Scenario: Trust / D-Price

	IM	ID	IC	NM	ND	NC
A	18.26, 14	12.07, 10	0.80, -1	**9.13, 16**	6.60, 12	1.80, 0
DA	7.43, -10	4.34, -2	2.80, -1	4.70, -8	3.43, 4	2.80, 0

(1- β)

Scenario: No Trust / D-Price

	IM	ID	IC	NM	ND	NC
A	**12.78, 10**	8.79, 6	1.40, -1	**3.65, 10**	3.31, -2	2.40, 0
DA	5.79, -12	3.79, -6	2.80, -1	3.05, -12	2.88, -2	**2.80, 0**

Note: Nash Equilibria for the game scenario represented in bold and highlighted.

on probability-weighted actions of the two types of Residents at a given trust prior belief (β ∊ [0,1]). **Figure 4** shows the two Trust Games, one for each type of Stakeholders, having a prior belief that the Residents are type Trust with a probability of β and type No Trust with probability of (1- β). Similar to the game with complete information, our results show that any given prior can have multiple Nash equilibria. This also means that multiple outcomes are possible given the players choosing certain options. **Table 2** show the frequency of Trust Games for each Stakeholders' game across the trust prior distribution.

Table 2: Frequency of Outcomes under an Uninformative Prior

Outcomes	Residents Action		Stakeholders Action	N-Price Type		D-Price Type	
	Trust	No Trust		N	Percentage	N	Percentage
Successful	A	A	IM	55	31.79%	1	0.83%
	A	DA	NM			29	24.17%
Sustainable	A	DA	ND	84	48.55%	57	47.50%
Unsuccessful	DA	DA	NC	34	19.65%	33	27.50%
			Total	173		120	

Each Stakeholders type game has one sustainable, and one unsuccessful Bayesian Nash equilibria. The N-Price type has one successful type of successful outcome where both types of Residents adopt the store, and the Stakeholders hire an influencer and maintain the store's upkeep. The D-Price type has two types of successful outcomes: a rare one similar to the N-Price successful outcome and a common one where they do not hire an influencer and do maintain the store's upkeep but only the Trust type Residents adopt the store. The more common successful outcome could be due the store being profitable despite no trust residents adopting the store given the immediate price discount. For both games, the sustainable outcomes occur the most across the trust prior distribution. A successful outcome occurs more often than an unsuccessful outcome for the N-Price Stakeholders, but not for the D-Price Stakeholders.

To visualize where Trust game outcomes lie on the trust prior distribution, we crafted violin plots which combine a boxplot and kernel density plot to visualize the distribution of the outcomes relative to the prior. Because the prior distribution is uniform, the violin plots are uniform. **Figure 5a**, shows the best N-Price store outcome only occurs when trust priors are 55% or below. If trust levels are 30% or below, the unsuccessful outcome can also occur. High trust levels for a N-Price store result in the sustainable outcome where the store upkeep is not maintained. **Figure 5b** shows majority of the best D-Price outcomes occur when trust levels are high (greater than 75%). As trust levels increase, the need to maintain the store for an optimal outcome also increases. If trust levels are low, the optimal outcome is to close the store. It is also important to note that the rare Nash for the D-Price type only occurs when Residents are 100% No Trust type. Compared to the N-Price type, the D-Price type shows less of an overlap between the outcomes.

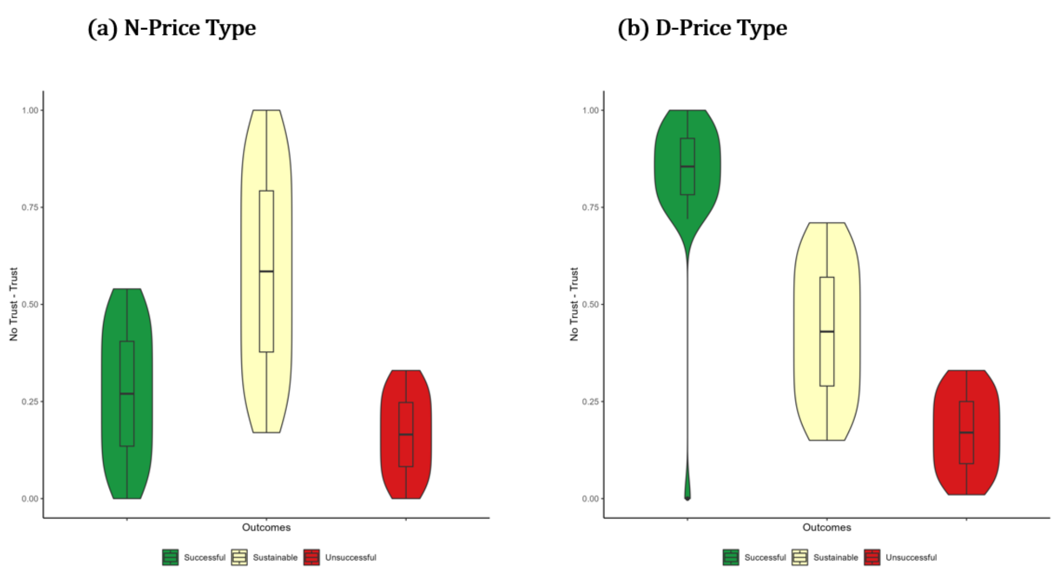

Figure 5: Violin Plots of Outcomes under One-Sided Incomplete Information
Note: These plots show a uniform distribution because they are conducted under a diffuse prior distribution.

For the N-Price Stakeholders, if trust is high, N-Prices stores can cut corners to make an optimal profit. If trust levels are believed to be moderate or low, they follow a go-big-or-go-home mentality and can either maintain the store upkeep and hire an influencer or simply close the store. For the D-Price Stakeholders, if trust levels are believed to be high, there is no need to hire an influencer to promote the store (unless under extreme conditions) but the No Trust type Residents do not adopt the store. If policymakers choose to create a N-Price store, they can have a successful outcome where both types of Residents adopt the store, but they are required to hire an influencer and find the optimal levels of trust, which can prove to be difficult. If policymakers choose to create a D-Price store, their store is more likely to be successful as trust levels increase but at the cost of the No Trust type Residents not adopting the store. This can prove fruitless if a majority of Residents are No Trust. The one-sided incomplete information Trust Games focus on residents' trust seems realistic; Residents can typically observe a store's type by analyzing their prices. However, without proper advertising or marketing, we cannot assume Residents know of the store's existence, let alone the store's type.

Policymakers should note that while each No Trust type scenario has an outcome that would improve food access in a community, there is also an outcome where the store can fail and close. This reflects the literature which documents that many food initiatives fail and only some are successful. If policymakers have built trust and would like to improve food access for a community, regardless of store type, they should ensure store operators maintain the store's upkeep. While the game highlights specifically N-Price stores may be incentivized to not maintain their upkeep because they gain a greater profit, this may only work in the short run. The duration of the game is four years, and eventually that store may close because Residents lose trust in it and frequent another store. Overall, the D-Price store is the best option because it provides a higher payoff for both players. Residents respond to discounted prices and believe the lower prices can compensate for the adjustment costs they may face from shopping at a new store. This increase in demand for healthy foods leads to an increase in profits for the store.

Case Study of Los Angeles Metro Area

Survey Based Prior Elicitation

The theoretical one-sided Trust Games were conducted under an uninformative prior, which provides no information on the likelihood of a particular Nash outcome occurring in the real world. This is problematic for policymakers designing a policy to encourage successful store openings given the outcomes of their policies are clearly conditional on the actual trust distribution in the areas where the policy will be implemented. Fortunately, prior belief distributions can be elicited from people without presenting them with the complete model and data being employed (van de Schoot et al., 2021). Prior elicitation focuses on developing and comparing prior belief distributions based on their informativeness. This process also means that information or data on the likelihood of a prior belief to occur can be used to create a more informative prior belief distribution (van de Schoot et al., 2021). This creates an updateable research cycle that improves as more information becomes available. Thus, applying an informative prior with trust levels derived from survey data can provide clearer insight, narrowing down the likelihood of each Nash outcome to occur given a population. This will aid policymakers in designing the best place-specific policies to maximize the probability a food initiative will be successful at bringing a grocery store to an underserved area.

To demonstrate the implication of this design in our theoretical model, we crafted an informative trust prior distribution derived from a small survey we conducted in the Los Angeles metro area. The resulting prior is formed from the empirical distribution of trust scores directly from the residents' responses to the trust questions on our survey. We then weight each possible outcome of the Trust Game conditional on each specific trust score by the frequency that trust score occurs in the survey-based prior. If a certain trust level did not have any respondents, then the outcome does not occur. Lastly, we created violin plots and frequency tables to compare the theoretical frequency of trust game outcomes to the actual, survey-reported levels of trust in the Los Angeles metro. It is important to note that these case study results are simply a small-scale demonstration application of our theoretical model.

Data

Two surveys were created to serve as the prior elicitation mechanism for an informative prior in the LFA Trust Games. The surveys include questions regarding whether respondents would adopt a new store in their neighborhood, and whether an influential person being involved would make them more likely to adopt the store. The surveys were based on the two Stakeholders' types in the Trust Game. The two surveys differ based on a prompt reflecting the differences in price of what the grocery stores offered. The consent form and the full survey questions are provided in **Appendices C**, **D** and **E**.

Following IRB approval, the surveys were conducted using a third-party company (Dynata) to survey their pool of participants in the Los Angeles metro area on December 7, 2022. The survey restrictions include respondents that were above the age of 18, had household income less than $75,000, and were the primary grocery shopper in their households. Both surveys included questions asking if the residents believed they were food insecure or living in a low food access area. Five hundred surveys were completed and after performing data cleaning, 495 survey respondents from 230 zip codes were used for the multivariate analysis (249 in the N-Price type survey and 246 in the D-Price type survey). Because trust questions were included in both surveys before they differentiate into questions based on two different types of grocery stores that are being proposed, the analysis utilizes the full dataset with 495 observations.

Case Study Results

A key focus of this research was to quantify residential trust and measure how residents perceive and value trust regarding various aspects of food and their community. To achieve this, we included questions centered on trust where respondents had to rate on a scale of 0-100 how likely they are to trust their local government and their government's decisions regarding food accessibility or quality of grocery stores closest to them. The individual trust ratings from the three trust questions were then averaged and scaled to create a composite trust score for that resident, ranging from 0 to 1. **Table 3** shows the summary statistics for the trust questions for the full dataset. Trust in their local government had the lowest average trust score, while trust in the quality of the grocery store closest to them had the highest average trust score of 0.69. **Figure 6** shows a map of the composite trust scores geocoded by their zip code. The darker blue areas denote areas of high trust while the yellow areas denote areas of minimal or no trust.

Table 3: Trust in Metro Los Angeles

Variables	Min	Q1	Median	Mean	Q3	Max
Trust in Local Government	0.00	0.29	0.51	0.51	0.76	1.00
Trust in Food Access	0.00	0.30	0.53	0.53	0.78	1.00
Trust in Quality of Grocery Stores in Area	0.00	0.51	0.73	0.69	0.90	1.00
Averaged Trust Score	0.00	0.41	0.59	0.58	0.77	1.00

N = 495

Note: This table provides the full data response to the trust question. The respondents were required to rate how likely they would agree to the following statements on a scale from 0% -100%. For example, respondents that select 50% regarding trust in local government should be interpreted as trusting their local government 50% of the time. The averaged trust score is the individual respondents average of their trust scores in the local government, food access and store quality.

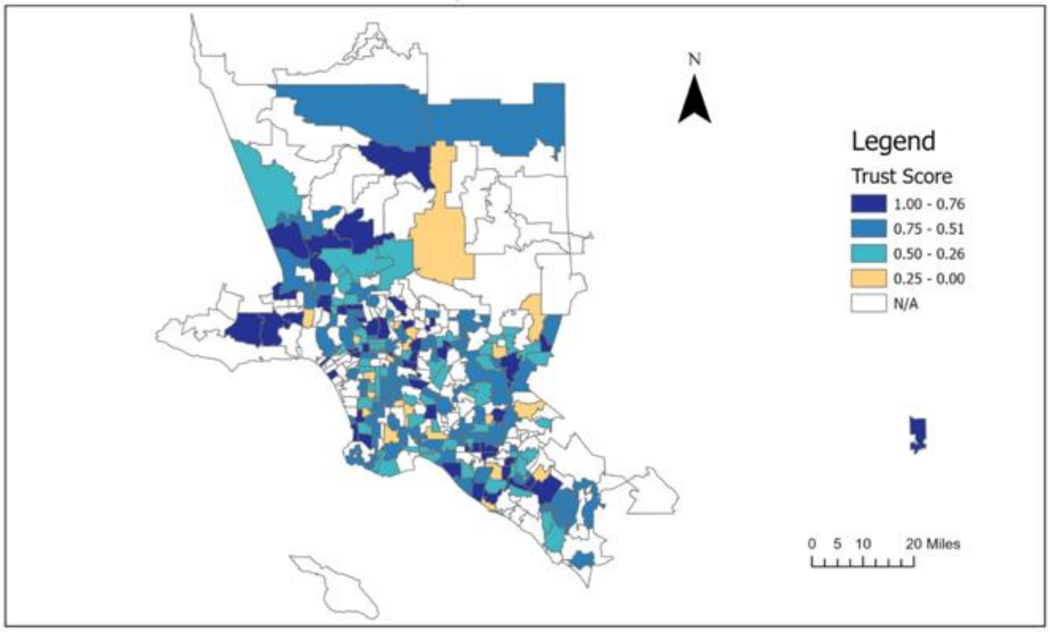

Figure 6: Trust Scores in the Los Angeles Metropolitan Area by Zip Code

The violin plots of the outcomes under the uninformative prior and the survey-elicited prior are shown in **Figure 7**. The middle histogram plot reflects the trust prior elicited from the survey. With the survey-based prior, the violin plots are no longer uniform, reflecting how the actual range of trust levels impacts the likelihood of each Nash outcome. For the N-Price type, there are more successful outcomes in the middle of the trust distribution, at trust scores close to 50%; for D-Price types, successful outcomes occur at high trust scores between 70% and 90%.

We see that the frequency of successful outcomes, in **Table 4**, is very similar across priors. A more interesting comparison is the differences between sustainable or unsuccessful outcomes. The uninformative prior has fewer sustainable and more unsuccessful outcomes for both types stores than under the informative prior. Our results highlight that incorporating actual data on the level of trust residents and tailoring policies to fit local trust levels could lead to more positive outcomes for food initiatives than an uninformed policymaker might guess. Overall, this research provides a framework policymakers can use to narrow down strategies for successfully opening a grocery store in an area. Continuing with the Bayesian statistical research cycle, more information can lead to a more informative posterior distribution that narrows the likelihood of the Nash outcomes even further.

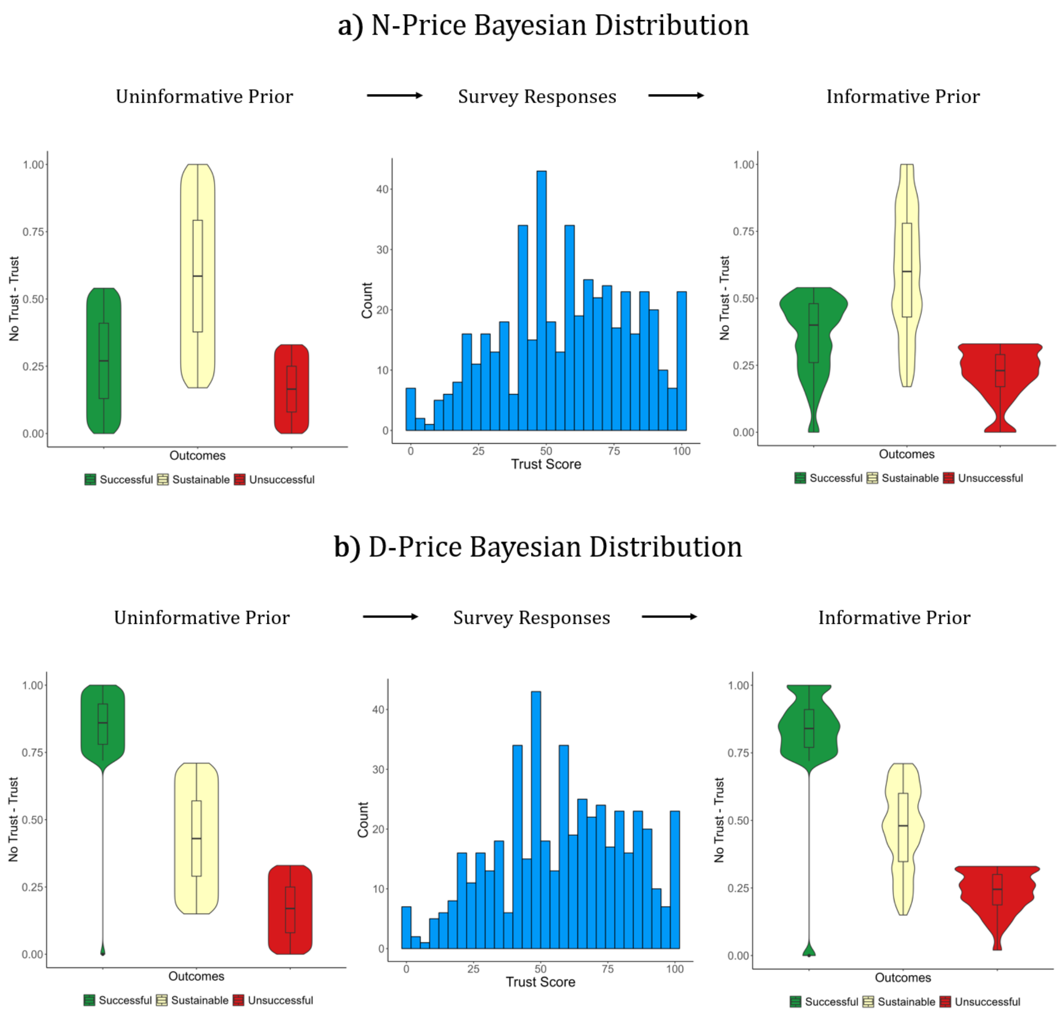

Figure 7: Bayesian Inference Violin Plot Comparisons

Table 4: Frequency of Trust Game Nash Outcomes by Prior Belief Distributions

Outcomes		Uninformative Prior		Informative Prior	
		Theory		Univariate Analysis	
		N	Percentage	N	Percentage
N-Price	Successful	55	31.79%	2270	28.52%
	Sustainable	84	48.55%	4740	59.55%
	Unsuccessful	34	19.65%	950	11.93%
Total		173		7960	
D-Price	Successful	30	25.00%	1670	29.25%
	Sustainable	57	47.50%	3160	55.34%
	Unsuccessful	33	27.50%	880	15.41%
Total		120		5710	

The small-scale prior elicitation exercise demonstrates that policies should be place-specific and that customizing policies to fit the locale can offer large benefits. Even over very small geographic areas, trust levels vary significantly and the resulting optimal policy can change. Overall, these prior elicitation results show that a more informative prior can narrow the Nash outcomes even further to pinpoint the trust levels needed to reach a successful outcome.

Policy Implications and Discussion

The Stakeholders in the LFA Trust Games are based on real governmental efforts that affect food access, food insecurity or encouraging healthy eating for low income residents: The Healthy Food Financing Initiative (HFFI), the Supplemental Nutrition Assistance Program (SNAP), the Gus Schumacher Nutrition Incentive Program (GusNIP), and the Let’s Move Campaign!.

The Healthy Food Financing Initiative (HFFI) focuses on improving food access for underserved communities by financing the opening of a grocery store

(Brinkley et al., 2019; Cantor et al., 2020; National Sustainable Agriculture Coalition, 2023). The initiatives' objective is to aid in initially funding a store, so they can overcome the high entry barriers for get establishing in an underserved community (National Sustainable Agriculture Coalition, 2023). Typically, a store funded by an HFFI grant only offers one healthy food price incentive program: the Supplemental Nutrition Assistance Program (SNAP). SNAP, formerly known as food stamps, is the largest food program geared towards limiting food insecurity by providing low-income households with money via electronic benefits transfer (EBT) cards to purchase groceries from SNAP allowable retailers. SNAP benefits are calculated in reference to the USDA Thrifty Food Plan, which calculates the minimum cost of a healthy diet (Fan et al., 2018).

Proving the relevance of our case study, California used HFFI funds to create California FreshWorks to improve food access for the underserved (Pacific Community Ventures, 2021). Since 2017, FreshWorks has leveraged over $79.6 million dollars in funding for retailers including grocery stores statewide, especially in the Los Angeles metro area (Pacific Community Ventures, 2021).

While the presence of HFFI-supported SNAP retailers has been shown to decrease food insecurity, there are mixed findings on whether they alter consumers' healthy eating habits due to their restrictions and eligibility requirements (Andrews et al., 2013; Barrett, 2002; Dubowitz et al., 2015; Gundersen & Ziliak, 2015). Hastings and Shapiro (2018) argue that households adopt a different mentality on how they spend SNAP benefits compared to cash, but this does not affect the amount of healthy and unhealthy foods that households purchase. Cuffey and Beatty (2021) find that opening a grocery store near a SNAP household leads to a higher proportion of SNAP benefits redeemed at grocery stores compared to ethnic and convenience stores. Overall, Allcott et al. (2019) conclude that policies aimed at eliminating food deserts benefit consumers less from healthy eating and more by increasing local food variety and decreasing travel costs.

In 2014, the Food Insecurity Nutrition Incentive Grant Program (FINI) was authorized to provide financial incentives (i.e., price subsidies) on healthy foods to increase fruit and vegetable purchasing and consumption among SNAP participants (Parks et al., 2019). In 2018, FINI funding increased, and the program was renamed the Gus Schumacher Nutrition Incentive Program (GusNIP). In 2021, The USDA Food and Nutrition Service reported 57% of GusNIP retailers were farmers markets and roughly one-third of GusNIP retailers were pre-existing SNAP retailers. Studies on GusNIP stores show positive impacts and altered eating behavior for food insecure households but highlight sustainability issues due to funding only being guaranteed for a couple years (John et al., 2021; Leng et al., 2022; Vericker et al., 2021). John et al. (2021) found that SNAP customers who frequented a GusNIP funded market in Rhode Island spent $10.54 more on fruits and vegetables because the store offered a 50% discount on all SNAP purchases.

In terms of the Bayesian Trust Games, the N-Price Stakeholders can be viewed as a HFFI subsidized store that accepts SNAP benefits; this is the more traditional attempt to alleviate problems in food insecure and low food access areas with prices being unaffected by any subsidies provided to encourage the store opening. The D-Price Stakeholders' store can be viewed as a GusNIP store and the less common solution to these problems, improving food access and providing healthy food at a price discount to encourage healthy eating.

Another important highlight from the Trust Games is the influencer. A person that is influential to the Residents can compensate for any distrust the Residents may have towards the Stakeholders. Celebrity influence has been shown to encourage healthy eating among food insecure people. In 2010, Former First Lady Michelle Obama led the Let's Move! campaign, which focused on reducing childhood obesity through physical activity and healthy eating. In conjunction with the campaign, Beyoncé reworked one of her songs to create a flash dance song "Move your Body" to boost the campaign. **Figure 8** shows a graph of the Google trends for “Let’s Move” and “Move your Body” over time. Not surprisingly given Beyoncé’s celebrity in the community, we find a boost in searches for “Let’s Move” after the song was released. This is an indication of the power that a trusted influencer can have.

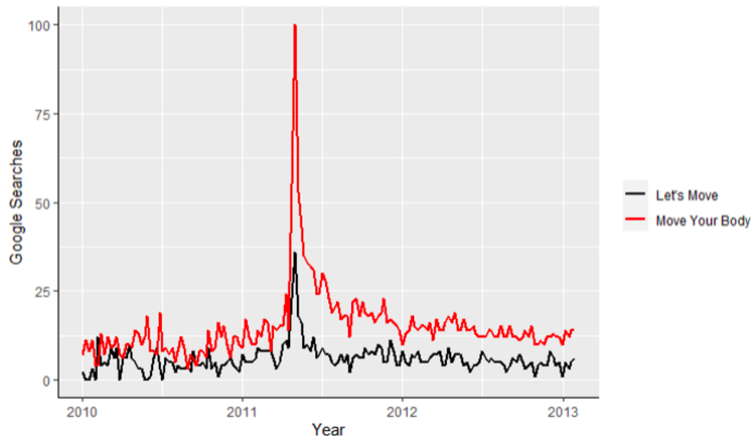

Figure 8: Google Trends Plot

Note: This plot shows google search for the Let’s Move Public Campaign vs. Beyoncé’s song Move Your Body.

Conclusion

Many underserved communities continue to disproportionately suffer from food insecurity and low food accessibility despite policies geared towards alleviating these issues, such as food assistance programs, government subsidies to lower the prices for healthy foods, and initiatives to open grocery stores in low food access areas. This paper shows some of the frequent failures of food initiatives documented in the literature likely stem from an overreliance on one-size-fits-all policies and insufficient attention to the specific community policymakers are attempting to help.

For policymakers, the Local Food Access Trust Game has three major contributions for alleviating these issues. First, it provides insight on the relationship residents and their local grocery store under a realm of uncertainty. Secondly, it showcases optimal win-win strategies for implementing a grocery store in an area and the choices needed to obtain it. Lastly, it provides a comparison between two store types across trust beliefs which both have their respective pros and cons. The LFA Trust Games shows varying factors that can affect residents' trust, including poor maintenance and upkeep, betrayal aversion from previous store closures at that location, the cost of adjusting to the store, and the inclusion of influencers. Intuitively, our results make sense: residents respond to price discounts, and communities with high trust are more likely to adopt a new grocery store as their primary location for purchasing healthy food, while residents with low or no trust are less likely to frequent a new store even with discounted prices or lower travel costs. Overall, the lessons learned here can potentially increase the efficiency of food initiatives meant to improve food access, affordability, healthy eating, and food security.

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