Influencers, Price Discounts, and Trust: A Game-Theoretic Approach and Application for Successfully Opening a Grocery Store

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We offer an explanation, particularly for the failure of the more local initiatives aimed to successfully open grocery stores in low food access neighborhoods, through a game theoretical model that addresses these problems by incorporating the role of trust within a community. Residents with high trust are more likely to adopt a new grocery store as their primary location for purchasing 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. The varying factors that can affect residents' trust, include poor maintenance and upkeep of the store, betrayal aversion from previous store closures at that location, the cost of adjusting to the store, and the inclusion of influencers. (*JEL* I38, C70, D11)

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Introduction

Food access, food affordability, and healthy eating are all concerns to policymakers, researchers, and ordinary people; yet many people still live in areas where food is difficult either to obtain or afford. Stores in neighborhoods without many other options have recently been closed or had closures announced due to financial underperformance (Tobin, Reuter, and Dean, 2023) and high rates of theft (Loeb, 2023). Anecdotes such as these make clear work remains to find the best policies to address food access. Toward this goal, 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). In this paper, we seek to highlight a minimally explored feature that can affect the success of opening a grocery store in an underserved area: trust within the community.

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). Trust within the community regarding food access can be gauged in a variety of ways including the reputation of, or past experiences with, grocery stores at a location. In an experiment regarding communication, promises and trust, Ederer and Schneider (2022) found that communication and committing to promises increases cooperation and trust by roughly 50 percent. They determined that, over time, trust sometimes must be repaid, and promises must be honored because they help foster belief in future actions that impact expected payoffs (Ederer and Schneider, 2022). It is also important to note that trust can be gained or lost based on actions and lead to betrayal aversion. Bohnet et al. (2008) note economic policies such as insurance can encourage and increase trust; however, if

consumers are too averse towards being betrayed based on past experiences, the payoff of such policies will have minimal effects.

Regarding food access interventions, if similar grocery store interventions have happened in a community in the past and they did not last long, then residents within that community will stop frequenting future stores at that location because they feel betrayed and do not trust the new stores to last long either. This creates problems for the grocery store because they are not making a profit. If residents, trust the store operators or government leading the food store initiative, they are more likely to adopt the store as their primary grocery store. If this group (store operators/government) decides not to maintain their store's upkeep, residents will be less likely to frequent it and more likely to return to their previous store despite the higher travel cost. This creates a paradoxical cycle which explains why researchers find a lack of success for grocery store openings in low food access neighborhoods. Ultimately, they can fail due to a lack of trust established with the community.

To understand more about the conditions or choices necessary for a successful store lasting in a low income and low food access area, we created a variation of the Trust Game focused on opening a 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).

There have been minimal studies that applied the Trust Game in the realm of alleviating food insecurity or low food access. The Grocery Store Trust Game presented here implements a Bayesian game theoretic model that imbeds residents' trust in government and store operators' decisions to open and maintain a grocery stores in a low income and low food access area. Our model can predict grocery

store success from a variety of food initiatives such as price discounts on relatively healthy foods, or involving an influencer that has trust within a given community. As an example of how this could be applied by policymakers, we apply a small consumer survey to derive respondents' perceived trust in the Los Angeles metro area and build an informative prior for the Trust Games.

This paper contributes 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. 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). Finally, 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 Model and Procedure

Structure of the Grocery Store Trust Game

The Grocery Store Trust Game is a non-cooperative game theoretic model that evaluates the decisions of two parties: the store operators/government and residents/shoppers. It can show the optimal choices and combinations for opening (and possibly closing) a grocery store in a low income and low food access area. It incorporates trust within a community and has the option of including the impact an influencer has within that community. A successful opening is defined as one that involves residents adopting the store as their primary grocery store and the operator renewing its lease on the store and maintaining the store upkeep.

Figure 1 shows the structure of the food access Trust Game. The game has two players: Stakeholders and Residents. The Stakeholders represent a partnership of the government and the grocery store operator. They make an agreement to open a subsidized grocery store in a low food access area. The Residents represent a low income and low food access community in which the grocery store will be opened. 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 four-year lease to open a grocery store close to the Residents' area.

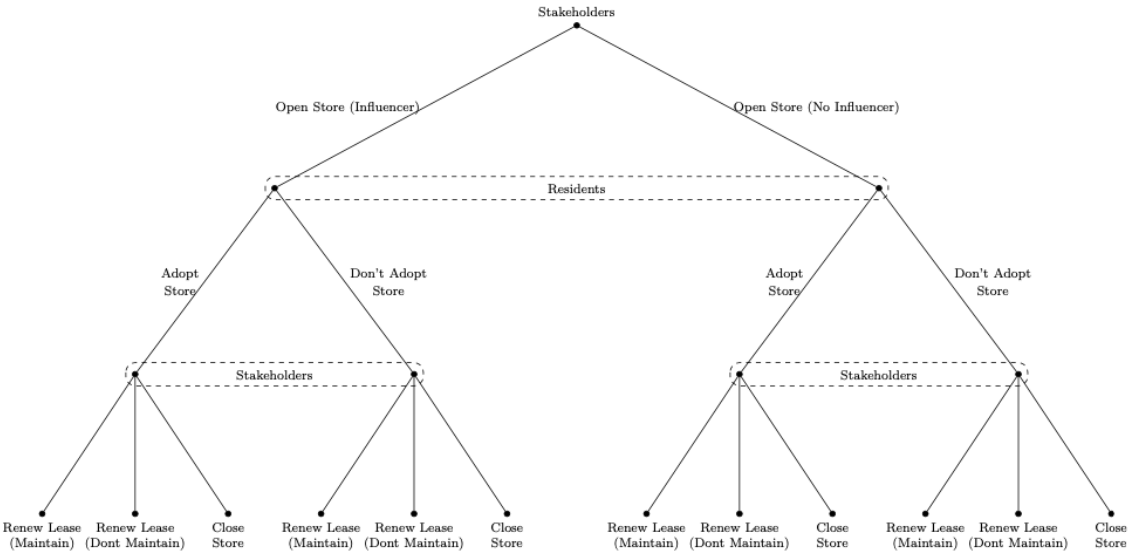


Figure 1: Structure of the Grocery Store Trust Game

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, and the Residents will react to the store and determine whether they want to adopt the store as their primary grocery store in purchasing their groceries. 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 new store because it is convenient. The Stakeholders then make the final move, and depending on the profits of the store, 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. 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 structure of the game. The entire duration of the normal form game is the term of the store lease. For the Bayesian variations of the game, each player has two types that operate under different motivations and have different payoffs; these are detailed later in this section.

The Stakeholders

The Stakeholders' payoffs are calculated based on profitability in dollars (π). Profitability of a grocery store in a low-income area is a major concern that requires developing cost-effective strategies that analyze the tradeoffs of demand-stimulating policies and supply side policies policy (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 in order 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 upkeep of the store to save money, producing a higher profit at least in the short run. This can be deemed as a form of persuasion because they are catering 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 more than 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 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 cost 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 have to include travel cost when deciding if they should frequent the store. **Figure 2a** shows the Hotelling model diagram from the perspective of the Grocery Store Trust Game, 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.

Typically, the Hotelling model shows the location for an "Indifferent Consumer" meaning 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 Stakeholders store's prices are preferred by the Residents because

when you include travel costs they are lower than the price they would pay at their usual grocery store.

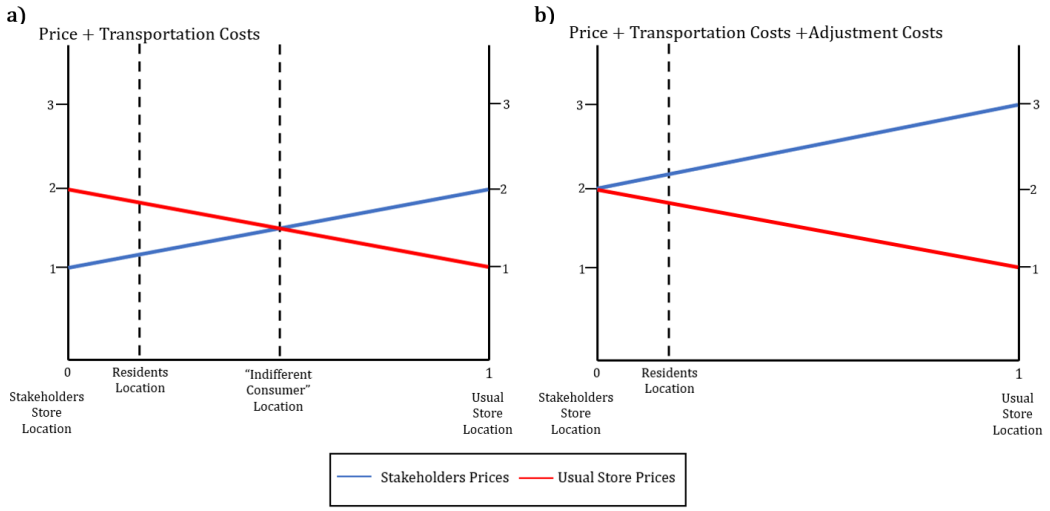


Figure 2: Hotelling Model Diagram

Now suppose, we expand on the basic Hoteling model and include the cost of preferences, trust, and inconvenience. The USDA Economic Research Service (ERS) reported that SNAP participants, on average live 1.96 miles from the nearest grocery store but travel 3.36 miles to their usual grocery store (Morrison and Mancino, 2015). This implies Residents include more than travel cost 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. If a new grocery store is built near Residents, 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 smaller 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 total net cost at the usual store is lower for the consumer.

For the Bayesian variations of the Trust Game, there are two types of Stakeholders that differ based on the programs allowed by the store that affect the price of healthy foods: The Supplemental Nutrition Assistance Program (SNAP) Stakeholders and the Gus Schumacher Nutrition Incentive Grant Program (GusNIP) Stakeholders. The Supplemental Nutrition Assistance Program (SNAP), formally 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 Thrift Food Plan that calculates the minimum cost for a healthy diet (Fan et al., 2018).

While the presence of 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 doesn't 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 that 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 SNAP Stakeholders' store can be viewed as the more traditional attempt to alleviate problems in food insecure and low food access areas through opening a new store accepting SNAP benefits from those that qualify, with prices being unaffected by any subsidies provided to encourage the store opening. The GusNIP Stakeholders' store is the less common solution to these problems, 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.

The Influencer

The influencer represents an optional partner included in the Stakeholders agreement. They are the first choice the Stakeholders make in the game. 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, over one-off campaigns, with influencers help increase the credibility of the business's product or brand. In our case, they can compensate for the distrust the Residents may have towards the Stakeholders by having an influencer endorse the new store.

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 and created a flash dance song "Move your Body" to boost the campaign. **Figure 3** 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.

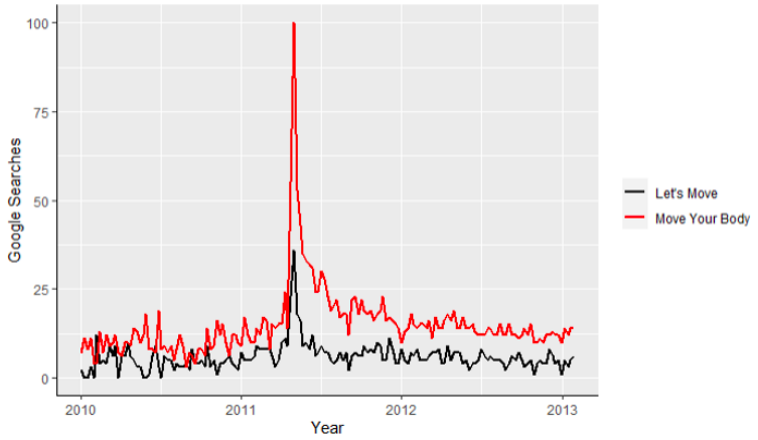


Figure 3: Google Trends Plot
Note: This plot shows google search for the Let's Move Public Campaign vs. Beyoncé's song Move Your Body.

Pei and Mayzlin (2020) created a game that focused on including an influencer in marketing a product and found that including an influencer can benefit the firm by raising awareness for a product and increasing the probability of positive review but depends on the costs, and consumers' prior beliefs. Hiring an influencer to market or endorse a product has already occurred in the fast food industry with the McDonald's Travis Scott Meal and Saweetie Meal, Burger King's Nelly Meal, and KFC's Jack Harlow Meal. One paper that focused on McDonald's partnership with Korean boy band BTS to create the BTS Meal in Indonesia found that "preference and role models influenced the buying behavior; however, these

factors influenced social empathy only when mediated by consumption" (Singer and Hidayat, 2021).

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 based 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 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,

$$P_{Hi} = P_R + C_{Ci}. \quad (1)$$

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

$$C_{Ci} = T_{Ci} + A_{Ci}. \quad (2)$$

We expanded 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 added 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

$$STS_i = Rep_i + Influencer\ Score. \quad (3)$$

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:

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

This shows how the store trust score *STS* and the adjustment costs within the 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 purchase their preferred groceries.

Highlighted by our food access 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 opened 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

$$Freq_i = \frac{v_i}{V}. \quad (6)$$

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 all each store's utility weighted by the individual frequency shares:

$$\Phi = \sum_{i=1}^{I} Freq_i U_i(X_{Hi}, X_{Ui}|STS_i) \quad s.t \sum_{i=1}^{I} Freq_i = 1. \quad (5)$$

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.

Game Structure

The Trust Game is played in normal form as shown in **Table 1**. 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 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 players' best action.

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	$(\Phi_{2,1}, \pi_{2,1})$	$(\Phi_{2,2}, \pi_{2,2})$	$(\Phi_{2,3}, \pi_{2,3})$	$(\Phi_{2,4}, \pi_{2,4})$	$(\Phi_{2,5}, \pi_{2,5})$	$(\Phi_{2,6}, \pi_{2,6})$

Table 1: Normal Form of the Trust Game

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,

$$Freq_{PS}^{M} > Freq_{PS}^{D} > Freq_{PS}^{C} \quad (4)$$

where frequency shares are ordered such that the maintained stores always have the highest frequency and the closed store has 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.

Bayesian Game Structure

Because each player has two types, there are four possible scenarios or combinations of Residents' type vs. Stakeholders' type. Under complete information, each player knows their type, and the other player's type. For example, The Trust type of Residents know the SNAP Stakeholders are opening the grocery store, and vice versa. Because there are two types of each player, there are four Trust Games encompassing each type combination of Stakeholders and Residents. While Trust Games with complete information assume that each player knows the other types, this may not occur in reality. To generalize to this more realistically, we created Bayesian Trust Games under the assumptions of one-sided incomplete information.

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. For example, if the Stakeholders open the grocery store and minimal Residents frequent the store after two years, the Stakeholders will believe they are the No Trust type of Residents. For our Bayesian Trust Games, we refer to the complete information Trust Games as scenarios because they show the strategies and payoffs of each type combination of Stakeholders and Residents. 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.

Results and Discussion

Baseline for Trust Games

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 the appendix. For the 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 specified prior beliefs occurring. All theoretical results were created and calculated using R.

Figure 4 shows the Trust Game Hotelling model used to motivate the full economic cost Residents face from both types of Stakeholders compared to their usual store. In this case, the retail price for healthy foods is normalized to equal $1.00 and the GusNIP type of Stakeholders' discounted price for healthy foods equals $0.50. The travel cost to the store equals $1.00 per unit of distance, and the adjustment/inconvenience cost of switching stores is $1.00. The blue line represents the prices for the proposed SNAP type store, the green line represents the prices for the proposed GusNIP type store, and the red line represents the prices for the other store. Similar to the original model, the Residents prefer the proposed store over their usual store if only travel costs are taken into account (**Figure 4a**) but this changes when adjustment costs are added (in **Figure 4b**). Now the SNAP store price is higher than the usual store price, and the GusNIP store price is still lower. Thus, whether Residents will frequent the proposed store depends on the store trust score and the level of adjustment costs anticipated (which is partially determined by the reputation score and the presence or absence of an influencer). Also, when adjustment costs are included, there is no longer an indifferent consumer for the SNAP store and the usual store because prices for the SNAP store are too high but there are still customers indifferent between the GusNIP store and their usual store.

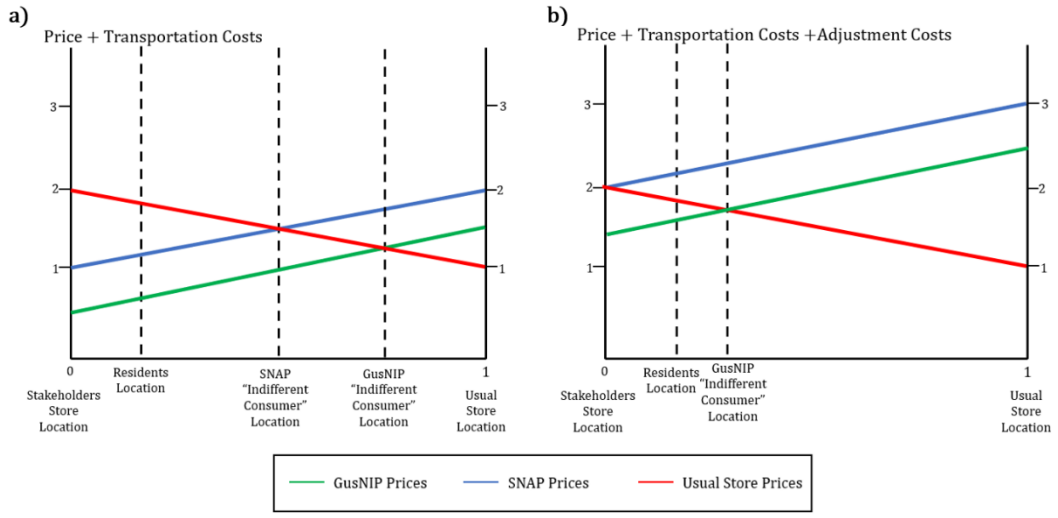


Figure 4: Hotelling Model for Bayesian Trust Games

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 SNAP type store was normalized to $1.00 for SNAP participants. The price for healthy food from the GusNIP type store was set to $0.50 for SNAP participants 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 SNAP 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 belongs 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 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.

Grocery Store Trust Games

Using the baseline values, we solved the four Trust Games scenarios as shown in **Figure 5**. Highlighted in each game scenario are the trust game outcomes under complete information. We find games with No Trust type Residents have two Nash equilibria, where one leads to a positive store outcome and one to an unsuccessful outcome. Both scenarios show the same unsuccessful outcome 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. A sustainable outcome is one where the store renews their lease but does not maintain their store's upkeep. This 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. A successful outcome for the game was defined as any Bayesian Nash equilibria that involves the Stakeholders maintaining their store's upkeep. Three out of the four positive store outcomes lead to a successful outcome.

The results show that to hire an influencer is only optimal under a successful outcome conditional that the Residents are type No Trust. For example, if Residents are type No Trust, regardless of Stakeholders' type, the Nash equilibria is where the Residents adopt the store, and the Stakeholders hire an influencer, renew the lease, and maintain the store upkeep. 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. The only sustainable outcome occurs if the Stakeholders are type SNAP, 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. This outcome makes sense because 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.

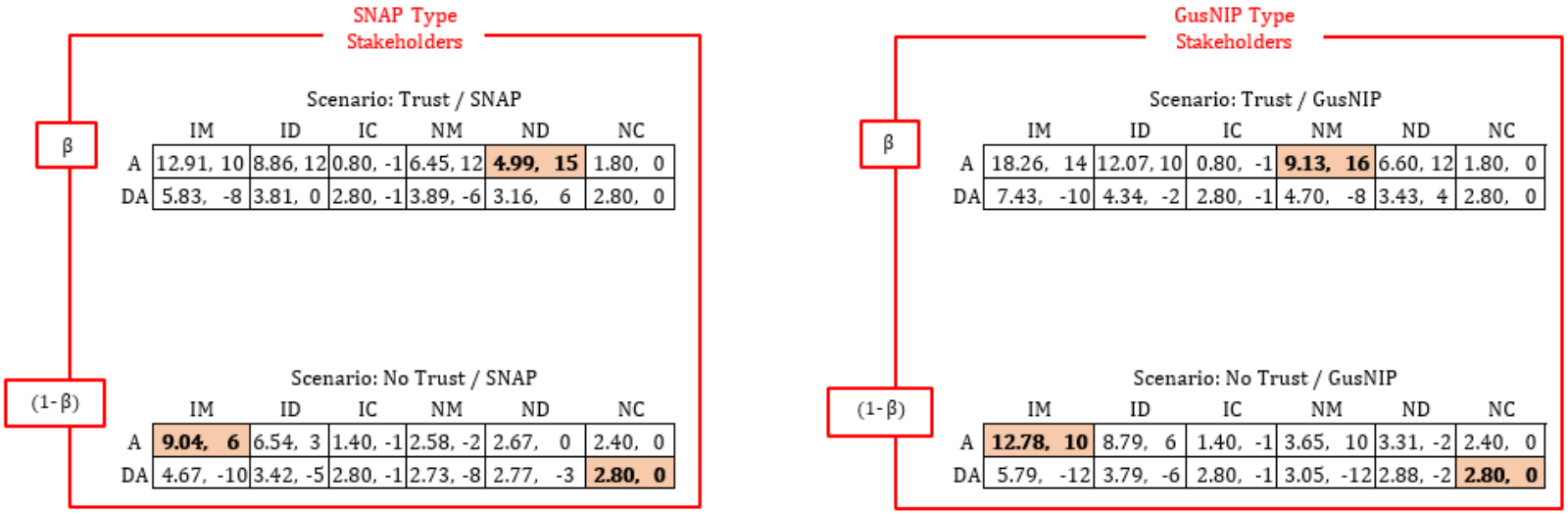
Suppose, Residents and Stakeholders knows their respective type but only the Stakeholders have uncertainty on the Residents type. This is the premise for a variation of the Trust Games under the assumption of one-sided incomplete information. In this case there are only two Trust Games, one for each 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.

The outcomes for the games can be interpreted as Bayesian Nash equilibria, where the optimal action for the Stakeholders depends on probability-weighted actions of the two types of Residents at a given trust prior belief ($\beta \in [0,1]$). **Figure 5** 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 α and type No Trust with probability of $(1- \beta)$. 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. For example, if the Stakeholders are type SNAP and their prior belief that the Residents are type Trust is 50% the Nash equilibria are ((A, A), IM) and ((A, DA), ND). The outcome ((A, A), IM) means that hiring an influencer and maintaining the store upkeep is an optimal choice for the SNAP Stakeholders given that both type of Residents adopts the grocery store. The outcome ((A, DA), ND) means that not hiring an influencer and not maintaining the store upkeep is an optimal choice for the SNAP Stakeholders given that the Trust type of Residents adopts the grocery store and the No Trust type of Residents do not adopt the grocery store.

Using an uninformative prior, we solved the game under the assumption of one-sided incomplete information. **Table 2** show the summary statistics for actions taken in the game for each type of Stakeholders across the trust prior of each Bayesian Nash equilibria. Each Stakeholders type game has one successful, one sustainable, and one unsuccessful Bayesian Nash equilibria. Of the games, the SNAP type has the best successful outcome where both types of Residents adopt the store, and the Stakeholders hire an influencer and maintain the store's upkeep. The more profitable outcome for the GusNIP type Stakeholders is where they do not hire an influencer and do maintain the store's upkeep but only the Trust type Residents adopt the store. 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 SNAP Stakeholders, but not for the GusNIP Stakeholders.

Figure 5: Normal Form Trust Game Scenarios



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

Table 2: Frequency of Trust Prior by Bayesian Nash Equilibria

Outcomes	Residents Action		Stakeholders Action	SNAP Type		GusNIP Type	
	Trust	No Trust		N	Percentage	N	Percentage
Successful	A	A	IM	55	31.79%		
	A	DA	NM			29	24.17%
Sustainable	A	DA	ND	84	48.55%	57	47.50%
Unsuccessful	DA	DA	NC	34	19.65%	35	28.33%
			Total	173		120	

Figure 6 presents violin plots to highlight the outcomes across a uniform prior distribution. Violin plots combine a boxplot and kernel density plot to visualize the distribution of the outcomes relative to the distribution of the prior. Because the prior distribution is uniform (uninformative), the violin plots are uniform. **Figure 6a**, shows the best SNAP store outcome only occurs when trust priors are 55% or below. If trust priors are 30% or below, the unsuccessful outcome can also occur. High trust priors for a SNAP store result in the sustainable outcome where the store upkeep is not maintained. **Figure 6b** shows the best GusNIP outcome occurs when trust priors 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. Compared to the SNAP type, the GusNIP type shows less of an overlap between the outcomes.

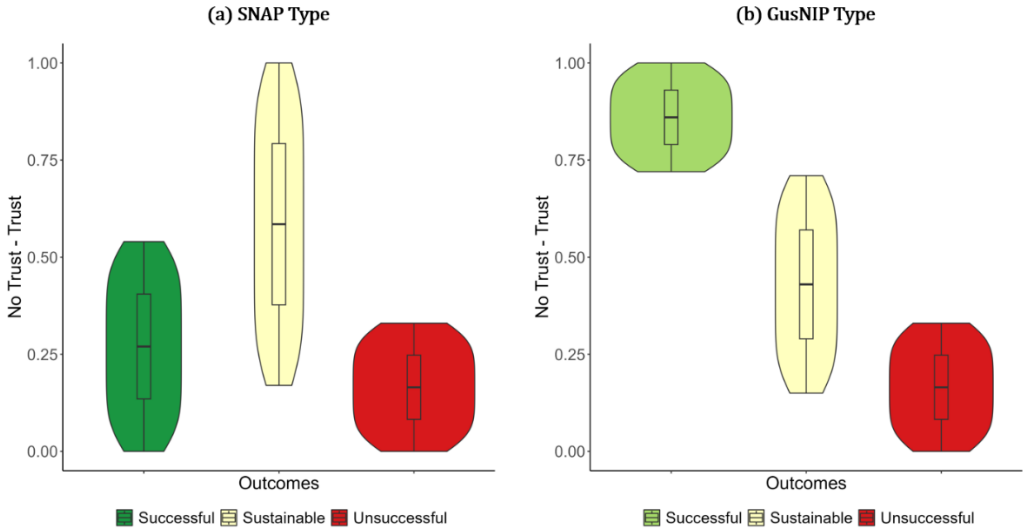


Figure 6: Violin Plots of One-Sided Incomplete Information by Bayesian Nash Equilibria
Note: These plots show a uniform distribution because they are conducted across a diffuse prior distribution.

Application

Prior Elicitation

Ideally, the objective when creating a theory is for it to reflect reality and constantly be up to date. Bayesian inference highlights this by focusing on the probability of an outcome based on prior knowledge or information (Box and George, 2011; Coletti et al., 2012). Prior belief distributions are beliefs held about a model and its parameterization before seeing the data (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. Bayesian inference has been applied to many topics but has been applied rarely in the realm of studying food access (Gebrie, 2021; Luan et al., 2015; Luan et al., 2016).

For example, the one-sided incomplete information Trust Games presents the optimal outcomes of opening a grocery store based on a diffuse prior distribution of trust from residents in a low income or low food access area. While this is more realistic than the complete information and two-side incomplete information games and provides more structure for policymakers to design these programs, the one-sided games presented earlier 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.

However, 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. We utilize survey respondents'

perceived trust in the Los Angeles metro area to derive an informative prior for the Trust Games. The objective is to apply the theory from the Trust Games with data to reflect reality within the community. These results show insight into how trust can play a factor in grocery store success. These results will provide policymakers the place-specific best design policies to maximize the probability a food initiative will be successful at bringing a grocery store to an underserved area.

The Survey Based Prior Elicitation

In order to focus specifically on the impact of trust, the responses from a small survey in the Los Angeles metro area were used to craft an informative prior distribution on trust. That is, the resulting prior is formed from the empirical distribution of trust scores directly from the residents' responses to the trust question 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. Violin plots and density plots were created to compare the differences in priors.

Data

Two surveys were created to serve as the prior elicitation mechanism for an informative prior in the grocery store 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 Stakeholders' types in the Trust Game: The Supplemental Nutrition Assistance Program (SNAP) Stakeholders and the Gus Schumacher Nutrition Incentive Grant Program (GusNIP). The SNAP store represents a traditional grocery store while the GusNIP store offers an immediate 50% discount on healthy foods. The two surveys differ based on a prompt as shown

in **Figure 7** reflecting the differences in price of what the grocery stores offered. The consent form and the full survey questions are provided in **Appendices**.

Figure 7: Prompt from Surveys

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 SNAP type survey and 246 in the GusNIP type survey).

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 2** 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 .69. **Figure 8** 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 2: 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.

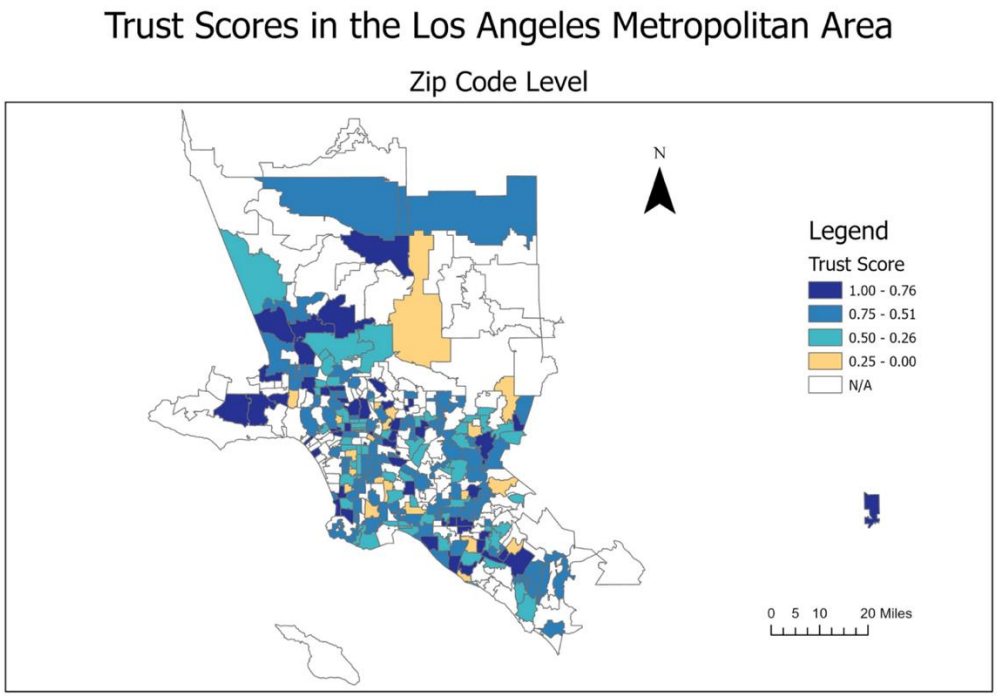


Figure 8: Map of Survey Respondents Trust Scores by Zip Code

In the theoretical model, the Stakeholders start with a choice to involve an influencer in the opening of the grocery store. The idea was to involve a person that was influential to the Residents and can compensate for any distrust the Residents may have towards the Stakeholders. To emulate this concept, a question was included to ask who the residents consider an influential person to their community. Hockberg and Hersch (2023) found that residents could identify an influential person their community and rarely consider a businessman an influential person. **Figure 9** shows a pie chart of the full data response to the question. A majority of respondents consider an expert in their field an influential person. This could possibly be due to the misinformation surrounding the COVID-19 pandemic (Loomba et al., 2021).

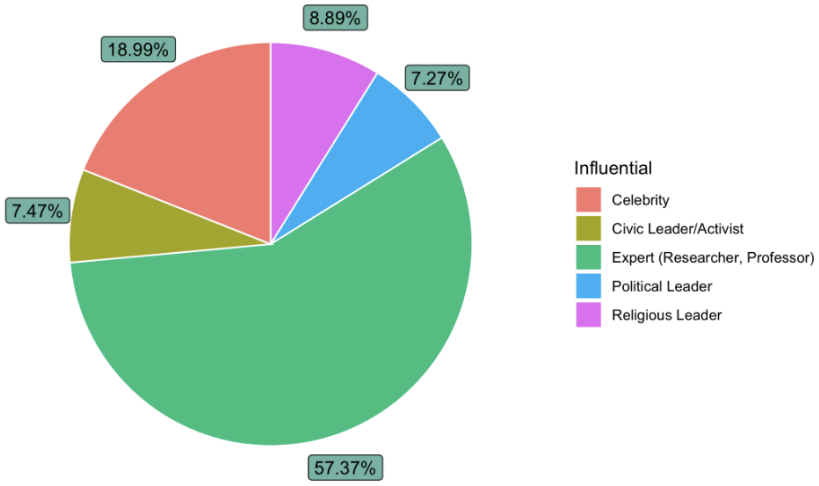


Figure 9: Pie chart of Resident's Influential Person

Trust Game Outcomes from an Elicited Informative Prior

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. **Figure 10** shows a violin plot comparison of the outcome distributions from the

uninformative prior to the survey-elicited informative prior. The middle histogram plot reflects the trust prior elicited from the survey. Note that with the survey information, the violin plots are no longer uniform and have some shape, reflecting how the actual range of trust levels impacts the likelihood of each Nash outcome to occur. For the SNAP type, there are more successful outcomes in the middle of the trust distribution, at trust scores close to 50%; for GusNIP types, successful outcomes occur at high trust scores between 70% and 90%.

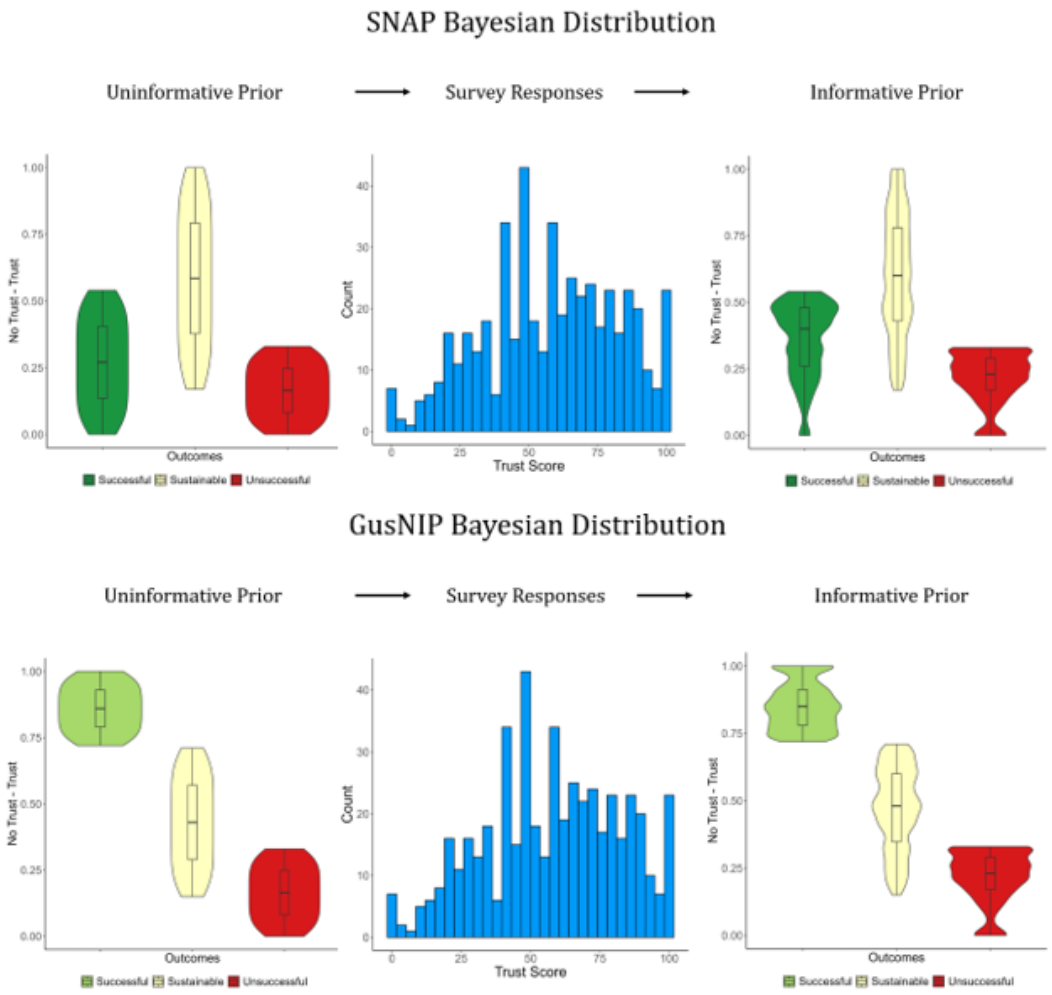


Figure 10: Bayesian Inference Violin Plot Comparisons

Discussion

For policymakers, the one-sided incomplete information trust game showcases a comparison between the two store types across trust beliefs which both have their respective pros and cons. For the SNAP Stakeholders, if trust is high, SNAP 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 GusNIP Stakeholders, if trust levels are believed to be high, there is no need to hire an influencer to promote the store but the No Trust type Residents do not adopt the store. If policymakers choose to create a SNAP 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 GusNIP 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.

Overall, the highest Nash payoff for both players and best-case scenario is where policymakers can 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 SNAP 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 GusNIP 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.

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. We offer an explanation, particularly for the failure of the more local initiatives aimed to successfully open grocery stores in low food access neighborhoods, through a game theoretical model that addresses these problems by incorporating the role of trust within a community. The Grocery Store Trust Game shows varying factors that can affect residents' trust, include poor maintenance and upkeep of the store, 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 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. The theory and empirical results shown here provide evidence that trust can be an important factor in the success or failure of food access-oriented policies. These games and the insights developed above 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. The small-scale prior elicitation

exercise demonstrates that results can be place-specific and that customizing policies to fit the locale can offer large benefits. Overall, the lessons learned here can potentially greatly increase the efficiency of food initiatives meant to improve food access, affordability, and security.

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