Modeling and Exploring Consumer Demand and Firm Investment Decisions

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Connor Allen

Approved by:
Major Professor: Jason Winfree, Ph.D.
Committee Members: Christopher McIntosh, Ph.D.; Phillip Watson, Ph.D.
Department Administrator: Christopher McIntosh, Ph.D.

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Abstract

The focus of this thesis is on modeling and exploring both firm investment decisions and consumer demand. The research presented analyzing three unique cases, two in which firm investment is the focus and take a theoretical approach to modeling firm investment decisions and a third case that empirically models and evaluates consumer demand. Firm investment is estimated in the cases of League Profit and Market sizes, with a focus in evaluating how teams choose the optimal market for league expansion and relocation then in the setting of a hypothetical food court in which vendors either compete or collude with on another and the investment choices made to optimize both the court and vendor returns. Consumer demand is investigated through modeling the market for different vodka types sold in the state of Idaho, presenting the unique structure of each market independently and analyzing how consumers of a given vodka chose to compliment and/or substitute their consumption of their choice alcohol with the alternatives available to them.

Beginning with our exploration on league market size and profitability; it is often assumed that sports leagues should have teams in the largest markets. However, our model shows that, depending on talent investment's role in team revenue, this is not necessarily true. Heterogeneity in markets sizes can not only decrease costs, but can also increase expected league revenue. Having a smaller market leads to an expectation that the large market team will win and creates less competition for playing talent. This creates a situation where leagues may prefer expansion teams to be in smaller markets or they want teams to relocate to smaller markets. Although there could be caveats, such as changes in consumer demand due to a decrease in competitive balance, greater market size differences can lead to higher league profits under general conditions.

Moving forward our paper next evaluates firm investment in the unique case of food courts. Employing our model to examines food courts, where vendors are competing with each other for a fixed number of consumers. This case may arise when consumers are traveling and patronize a food court, or if the destination is a food court. A contest success function is used to describe consumers' choices, as well as vendor investment and profitability. Using a contest success function allows for varying degrees of substitution between the vendors. Substitution can be a function of location or product space. The model analyzes revenue sharing and changes in product differentiation when aggregate demand for the food court is fixed. The model is also examined if the food court has a collective reputation that depends upon the average investments of each vendor.

Switching gears, this paper next examines consumer demand; through the market for vodka in the State of Idaho, exploring consumer demand for and consumer consumption of vodka. Using data provided by the state of Idaho, vodka is classified into one of five distinct types, from here a model is developed and employed to explain the demand for vodka. Own price, price of substitutes (wine, beer, other vodka types, and all other liquor), consumer income, unemployment, and population are all employed in the regression. Month, year, location of the sale (Store ID number) and months in which Covid was a factor are also controlled for. This research provides some evidence that each individually classified vodka is a unique separate market from the summation of all vodkas as one market, and further, all alcohols as one market. With each specific type of vodka having its own unique demand and consumption behavior to be analyzed and modeled independently.

Acknowledgements

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1 Sports League Profit and Market Sizes

1.1 Introduction

At least since Rottenberg (1956), economists have suggested that consumer demand may be influenced by competitive balance, and therefore relatively equal markets for teams may be preferred. Since investment in talent is a function of market size, this implies that leagues may want relatively equal market sizes leading to balance. This suggests that if incumbent teams already occupy the largest markets, new teams should enter the largest available markets to ensure balance and a large fan base for the league. Many studies have empirically estimated the effect of competitive balance on the demand for sports and the results seem mixed. However, the cost side of having evenly matched markets and teams is less studied. This study shows that teams of dissimilar market sizes will invest less in quality, and may even have higher expected league revenues. In other words, competitive balance leads to more competition on the labor market and possibly even less total league revenue. This implies that increasing the fan base of the small market team can hurt the league's profitability. Therefore, when leagues expand or relocate, it is not obvious that one of the largest available markets should be chosen.

These incentives are similar to those analyzed in Fudenberg and Tirole (1984). In their paper they show that profitability relies upon the expectations of your competitors. For example, if a firm can signal low investment, then competing firms may also have a low investment depending on the degree of substitution. We analyze this in the sports context, where teams in small markets may have little incentive to invest in talent, thereby allowing larger market teams to invest less (Fat Cat Effect).

We use a very general, and much used, model of a two-team sports league to calculate league profits. A very basic model is used to show the generality of the results. Using the typical model of a sports league, where teams invest and a winner is determined through a contest success function (CSF), yields some interesting results when allowing the market sizes to vary. Somewhat intuitively, having one very small market decreases costs for both teams because there is less competition for players or other investments. Perhaps less intuitively, having a very small market can increase expected league revenue. This is because the large market team has a higher probability of winning as the small market gets smaller. Since a larger market may create higher costs as well as lower revenue, the optimal size of the market of an incoming team is not clear.

There are some caveats. Besides the aforementioned impact of competitive balance on consumer demand, total league talent investments could also impact consumer demand in an open league, where leagues compete for players with other leagues. For example, some leagues may want more competition in the labor market so that aggregate talent levels increase and thereby raise league revenues. This would not be the case in a closed league where presumably all the best players are already in the league.

Our model also assumes that revenues are dependent upon winning, which is then dependent upon talent investments. If revenues are simply dependent upon the number of fans, and less dependent upon winning, then leagues would want larger market sizes. Also, our model assumes that winning is dependent upon talent investments. In other words, that player salaries are correlated with winning. In a league where winning is not determined by playing talent, leagues would prefer to have all large markets.

However, we argue that for many sports leagues, the relationship between player investment and team success, as well as team success and consumer demand, is more clear than the relationship between competitive balance and consumer demand. Our assumptions are also in line with most of the literature regarding sports league modeling. So, while we focus on market sizes, the model assumptions are very consistent with the literature. Our model shows that under general conditions, leagues might be more profitable with an increase in heterogeneity with regard to market sizes. Therefore, either the often used assumptions in sports league modeling are incorrect, or this has direct implications for league expansion and team relocation.

1.2 Literature Review

Our paper follows the theoretical model of Szymanski (2004) and Szymanski and Késenne (2004), and is an extension of the model found in Winfree (2020). We use a common CSF to find optimal team investments, and assume that leagues are maximizing profits. However, unlike previous studies, we focus on market sizes and how they relate to league profits. Whereas the previous literature take markets sizes as exogenous, we apply our model to league expansion or relocation where the decision of the location of teams suggests market sizes are endogenous.

This study ties directly to the literature of sports league expansion and market sizes. Much of the league expansion literature focuses on how the individual teams make site selection decisions. For example, Rascher and Rascher (2004) analyze potential expansion markets for the National Basketball Association (NBA); using data from incumbent U.S. markets that have NBA franchises to determine the relationship between revenues and market characteristics. This estimation is then used to forecast the relative likelihood of other cities being similar enough to NBA cities that support a team. Revenue forecasts are then generated for new markets. While they point out that smaller markets may be viable due to other factors, such as a better stadium lease, the assumption is that markets should be chosen based on their capacity to generate revenue. Similarly, Rascher et al. (2006) creates a model that ranks current and potential MLS cities based on their financial promise and market characteristics.

Investigation revolves around market characteristics that influence a city's "success" in supporting a team, economic factors affecting success, and factors that caused failures in other cities that have folded as MLS franchises.

Bruggink and Schiz (2007) evaluate potential relocation and expansion sites for the National Football League (NFL). They examined 50 metropolitan areas based on demographic and economic factors and concluded that the markets of Los Angeles (which did not have a team at the time of the study but currently has two) and San Antonio would be the best locations for an expansion or relocation team and the smaller markets of Buffalo and Jacksonville are vulnerable of losing their teams. Poplawski and O'Hara (2014) create a model that estimates financial viability in the National Hockey League (NHL) in light of the Collective Bargaining Agreement (CBA) at the time. They found that small market teams are viable under the CBA and can be successful thanks in large part to the league revenue sharing, salary cap, and player's share of league revenues brought about by the changes in the CBA.

This study however expands upon and differs from the existing body of literature by focusing on league wide profits serving as the motivation for adding expansion teams whereas in the previous studies the emphasis has been on expansion or relocation being motivated by the individual team profits. The key difference that is observed here is while the largest markets may be in the individual teams interest to maximize their own profit, it may be the case that the league prefers for teams to be located in a variety of different sized markets.

Other papers focus on the optimal size of a league. Kesenne (2009) uses a theoretical model to investigate the optimal size of a sports league. The model primarily focuses on the variables that affect league quality, specifically, the number of teams, average talent level of teams, winning percentage of the teams, and competitive balance to show that the number of teams in a monopoly league is fewer than the welfare optimal number of teams in a league.

Kahn (2007) studies sports league expansion and consumer welfare. The chief assumption being that as a sports league expands, the average quality of playing talent falls, which in turn imposes a negative externality on fans as each fan sees the leagues superstars fewer times per season. The study shows that if revenues come from local sources (gate receipts and local media) then the monopoly league size that maximizes total league profits is the optimal league size and the competitive league size is too large. However, if all revenues are national, split evenly, and where a broadcast network charges a uniform national price to viewers, the optimal league size is between the larger competitive size and the smaller monopoly league size. As the supply of talent becomes more elastic, the closer the competitive size is to the optimum.

Noll (2003) focuses on league contraction as opposed to expansion. He shows that more revenue sharing increases the incentive to eliminate weak franchises. This analysis is then used to structure an examination of baseball's financial data from 2001 to determine the effects of contraction on other teams and on society. He argues that Major League Baseball (MLB) teams generate positive net social benefits, but the existing teams would benefit by approximately one billion dollars from the elimination of the two weakest teams.

While some of the ideas regarding optimal league size are similar to our paper, our model assumes the number of teams is fixed. So, while we are also concerned with the impact of talent supply and team market sizes on league profitability, our model is quite different since we do not compare leagues with different numbers of teams.

This study is also related to the competitive balance literature. More specifically, if competitive balance is a large factor in generating revenue, it may be the case that relatively equal market sizes are optimal. However, empirical evidence seems to suggest that competitive balance is a relatively small factor in league revenues (for surveys see Szymanski (2003), Borland and MacDonald (2003) and Coates et al. (2014)). Therefore, if revenues are not greatly influenced by competitive balance, then investment costs may be a driver of league profitability.

1.3 Theoretical Model

This section models the effects of the market size of an incoming team on investments, winning, revenues and profits. Our model has two teams and two stages. In the first stage, an incoming team chooses a market. In the second stage, the incoming team and incumbent team choose their talent investment which decides their winning percentages, revenues and profits.

Therefore, in the first stage there is an incumbent team and an incoming team will enter the market and has a choice of market sizes. While the incoming team may not have access to unlimited markets, there may be some variability and it is not obvious how the market size will impact league profits. We examine league profits because even if the incoming team would prefer a particular market, their entrance into the league may depend upon league profits. For example, if there is some negotiation between the entering and incumbent team, perhaps through a franchise fee, then the incentives of the entering team and the incumbent team may align. That is to say, in many sports leagues it is ultimately the incumbent team or teams that decide which markets can expand into the league.

Once the market is chosen, then each team invests in talent, which leads to winning, which is determined by the CSF. The teams' winning percentages then determine revenues and therefore profits. Thus, it may be in the best interest of the league to choose a small market, so that both teams invest less in talent (e.g. Fat Cat Effect).

Using backwards induction, we start with the second stage and model the effect of talent investments on winning and revenue. Each team invests in talent which leads to a winning percentage. For a CSF, we use a Tullock (1980) or ratio CSF, which is common in the sports economics literature. Winning depends upon the ratio of investments such that team i's winning percentage is given by,

$$w_i = \frac{x_i^\gamma}{x_i^\gamma + x_j^\gamma} = 1 - w_j \tag{1}$$

where x_i is the investment made by team i and $0 \leq \gamma < 2$.[1] γ determines the relationship between investment and winning. If γ is low, then effect of investment on winning is small and the two teams' winning percentages would be relatively equal. If $\gamma = 0$ then talent investments have no impact on winning. As γ increases, winning percentages are more spread apart. In general, winning increases when talent investment increases, $\frac{\partial w_i}{\partial x_i} > 0$, winning decreases when the opposing team increases talent investment, $\frac{\partial w_i}{\partial x_j} < 0$, and the cross-partial derivative is positive for the team that has invested more in talent, $\frac{\partial^2 w_i}{\partial x_i \partial x_j} > 0$ if $x_i > x_j$. Winning then determines the teams revenues so that $R_i = \sigma_i w_i$, where σ is an exogenous parameter that reflects the market size. We assume that for team j, $R_j = w_j$, which is the equivalent of $\sigma_j = 1$. Therefore, we drop the subscript for σ as it only pertains to team i.

The objective function for team i is given by,

$$\pi_i = \sigma \left(\frac{x_i^\gamma}{x_i^\gamma + x_j^\gamma} \right) - x_i \tag{2}$$

Solving the first order conditions show that the equilibrium investments are given by,

$$x_i = \frac{\gamma \sigma^{\gamma+1}}{(1 + \sigma^\gamma)^2} \tag{3a}$$

[1] Baye et al. (1994) shows that if $\gamma > 2$ then there may be mixed solutions.

$$x_j = \frac{\gamma\sigma^\gamma}{(1+\sigma^\gamma)^2} \tag{3b}$$

Figures 1 and 2 show the investments for each team for different levels of γ. With the exception of low levels of σ, as γ increases, so does the equilibrium talent investments for both teams. If $\sigma > 0.3$, a more deterministic CSF (higher γ) implies more investment. Also of note is that investments can start to decrease as σ gets larger.

Given the investment levels for each team, team i's and j's winning percentages are given by,

$$w_i = \frac{\sigma^\gamma}{1+\sigma^\gamma} \tag{4a}$$

$$w_j = \frac{1}{1+\sigma^\gamma} \tag{4b}$$

Figure 3 shows how the winning percentages change for both teams for various levels of σ if $\gamma = 1$. Figure 3 illustrates the level of competitive balance as a function of σ. As expected, the winning percentage of the small market team increases as their market increases.

Given the equilibrium investments, team profits are given by,

$$\pi_i = \frac{\sigma^{\gamma+1}}{(1+\sigma^\gamma)} - \frac{\gamma\sigma^{\gamma+1}}{(1+\sigma^\gamma)^2} \tag{5a}$$

$$\pi_j = \frac{1}{(1+\sigma^\gamma)} - \frac{\gamma\sigma^{\gamma}}{(1+\sigma^\gamma)^2} \tag{5b}$$

Figure 4 shows the effect of market size on team profits for both teams when $\gamma = 1$. The effect of market size on the incoming team is given by,

$$\frac{\partial\pi_i}{\partial\sigma} = \frac{\sigma^\gamma}{(1+\sigma)^3}\left[1-\gamma^2+\sigma^\gamma(2+\gamma)+\sigma^{2\gamma}\right] \tag{6}$$

While this effect is not always positive, it is positive if the team's profits are positive, meaning that as long as team i is operating profitably and their optimal choice of talent is not zero, a marginal increase in the market size is to their benefit.

The league may be able to coordinate which markets to enter. For example, if the league allows entry if a team pay a franchise fee that is dependent upon which market the team enters, then the league may be able to maximize joint profits. The total league profit is given by,

$$\Pi = \frac{1+\sigma^{\gamma+1}}{(1+\sigma^{\gamma})} - \frac{\gamma\sigma^{\gamma}+\gamma\sigma^{\gamma+1}}{(1+\sigma^{\gamma})^2} \tag{7}$$

Total league profits under various degrees of σ (γ is assumed to be equal to 1) are shown in Figure 5 and illustrate that it may not be in the league's best interest to find the largest market. While having equal markets, $\sigma = 1$, does not minimize league profits, league profits are maximized when σ is very small or very large. This relationship can also be shown by setting $\gamma = 1$ and taking the derivative of equation (7) with respect to market size, showing the effect of market size on league profits.

$$\frac{\partial \Pi}{\partial \sigma} = \frac{\sigma^2+2\sigma-2}{(1+\sigma)^2} \tag{8}$$

Even in this restrictive case where $\gamma = 1$, the derivative cannot be signed, implying that a larger market does not always increase league profits. Under these parameter values, the derivative equals zero when $\sigma = \sqrt{3}-1$. Therefore, below that value, the league loses profits as team i chooses a marginally larger market. Above that value, league profits increase as the market size of the incoming team increases.

There are a couple of reasons why profits are not maximized with the largest possible market sizes. Perhaps most obvious, is that total investments increase as σ increases. This implies that similar market sizes will increase costs. This relationship is shown in Figure 6 for the case where $\gamma = 1$. Perhaps less obvious is that revenues do not always increase as σ increases. Figure 7 shows that at some levels of σ league revenues decrease as the small market becomes larger. This is because at low levels of σ, an increase in the small market size increases the probability of the small market team winning, which in turn decreases league revenues.

1.4 Example

Suppose that $\gamma = 1$ and there are only a finite set of markets available for a new entrant. Table 1 shows the profit for the entrant, incumbent, league, and the change in league profit. For example, suppose you have to choose from the set $\sigma =$ (i) 1.7 (ii) 1.3 (iii) 0.9 (iv) 0.5 or (v) 0.1. If the league is maximizing total profit then the ranking of the markets is given by (v), (i), (ii), (iv) and (iii), such that the most balanced market ranks last. This is because more balance leads to more competition in terms of investments and therefore higher costs, while imbalance limits competition and therefore has collusive benefits. Market size is a strategic substitute. As the table shows, the unambiguous benefit of the larger market only becomes apparent when $\sigma > 2$.

1.5 Caveats

1.5.1 Consumer Demand and Uncertainty

While Figure 5 shows that under reasonable conditions league profits are maximized at the lowest levels of σ, Figure 3 also shows that this happens when there is virtually no competitive balance. It could be the case that league profits are maximized when market sizes are unbalanced, but at some point, fans may want a reasonable level of balance. As stated in the literature review, the evidence is mixed that competitive balance drives consumer demand. However, this is empirically tested at current levels of balance, which is not at the extreme values.

It may be the case that fans enjoy some level of unbalance. There is some evidence that some people prefer to root for underdogs (Vandello et al., 2007), which cannot happen without some level of imbalance. The NCAA men's basketball tournament routinely markets "Cinderella stories" and showcases upsets, which cannot happen without mismatched opponents. Many fans might argue that Tiger Woods in his prime was good for golf even though he decreased competitive balance. Nonetheless, leagues should be aware that having disparate market sizes may have advantages, it may also run the risk of hurting overall league demand.

1.5.2 Consumer Demand and League Talent Levels

Another issue is whether or not fans care about league talent levels. This may not be an issue in "closed" leagues where league talent levels are fixed and teams distribute talent between themselves, but in "open" leagues where teams compete for talent across other leagues, total league investments may have a direct impact on consumer demand. Just as the case of uncertainty, this may be something for leagues to consider when determining optimal market sizes.

This could be modeled with the following profit functions: $\pi_i = \sigma(w_i + \xi \ln(T)) - x_i$ and $\pi_j = w_j + \xi \ln(T) - x_j$ where T is equal to the league talent level and ξ is a parameter measuring consumer preference for league talent levels. In a completely open league, the league talent level is equal to the sum of investments, $T = x_i + x_j$. While this model is tractable when $\gamma = 1$, if ξ is large enough it may give an incentive for the smaller market to have an investment of zero. However, in this example there is a benefit of team investment separate from the impact of winning. This preference for higher league talent levels would mitigate any benefits from having disparate market sizes.

1.5.3 Different Revenue Functions

Another caveat is that revenue functions may be dependent upon market size, but not dependent upon winning. In our model revenue depends on winning. While this model may work well for identifying qualitative effects of policies on competitive balance, it may not truly represent revenue structures. At the extreme, if revenues are only a function of market size, but do not depend upon winning, choosing a smaller market size would clearly decrease total league revenues and profits. Our model shows the effects of having various market sizes to the extent that revenues depend upon winning.

Empirical evidence seems to suggest that player investments heavily influence team quality (Peeters, 2011), and team quality is a major determinant in team revenue (Bradbury, 2019; Winfree, 2020). Therefore, it is certainly reasonable that leagues can impact total investments, and expected revenues, when they decide which markets to enter. Further, it is not only which markets to enter, but also the decisions regarding how many teams to have in certain markets that can change the marginal revenue curve with respect to winning (Mongeon and Winfree, 2013). Since investments, winning, revenues and market size seem to be highly correlated, our model has implications on league profitability.

1.6 Conclusion

It is often assumed that leagues always want teams in the largest markets possible. However, our model shows that this is not the case based on an often used model of a sports league. Having one large team and one small team has benefits in that there is less competition for players and the large market team increases their revenue. Under reasonable conditions, there is a minimum league profit when one team is slightly smaller than the large market team. In other words, there may be a point where a small market team is large enough to drive up league investment costs, and small enough that when they win it decreases league revenues.

There are other reasons why leagues may want to maximize market sizes. For example, having one large market team and one very small market can create an unbalanced league, low levels of absolute talent for the league, or losses in revenue that is not dependent upon winning. However, empirical evidence suggests that balance and uncertainty of outcome is not always critical for leagues. Also, for many "closed" leagues, absolute talent levels are not a concern. Further, winning has been found to be a large determinant in team revenues for many leagues. So, while these factors may mitigate the effects of the model, leagues may want to be cognizant of the effects on talent investment and league revenues with having homogeneous markets.

Table 1: Market Size and Profits

σ	Entrant Profit	Incumbent Profits	League Profit	Derivative of League Profit
0	0.000	1.000	1.000	-2.000
0.1	0.001	0.826	0.827	-1.479
0.2	0.006	0.694	0.700	-1.083
0.3	0.016	0.592	0.608	-0.775
0.4	0.033	0.510	0.543	-0.531
0.5	0.056	0.444	0.500	-0.333
0.6	0.084	0.391	0.475	-0.172
0.7	0.119	0.346	0.465	-0.038
0.8	0.158	0.309	0.467	0.074
0.9	0.202	0.277	0.479	0.169
1	0.250	0.250	0.500	0.250
1.1	0.302	0.227	0.529	0.320
1.2	0.357	0.207	0.564	0.380
1.3	0.415	0.189	0.604	0.433
1.4	0.476	0.174	0.650	0.479
1.5	0.540	0.160	0.700	0.520
1.6	0.606	0.148	0.754	0.556
1.7	0.674	0.137	0.811	0.588
1.8	0.744	0.128	0.871	0.617
1.9	0.816	0.119	0.934	0.643
2	0.889	0.111	1.000	0.667

Figure 1: Investment i with different $\gamma values$

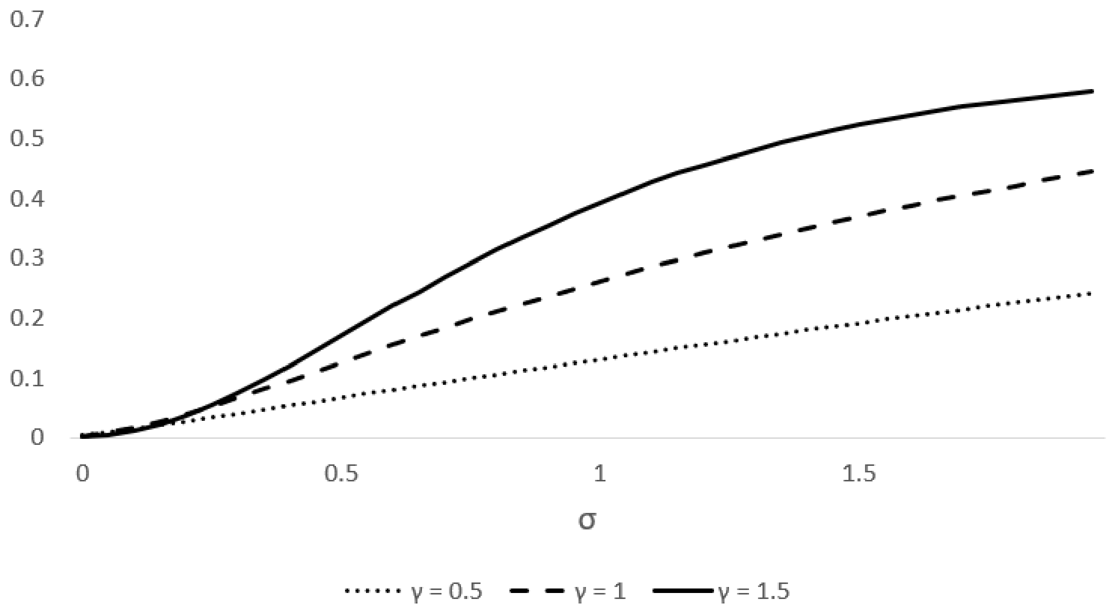


Figure 2: Investment j with different $\gamma value$

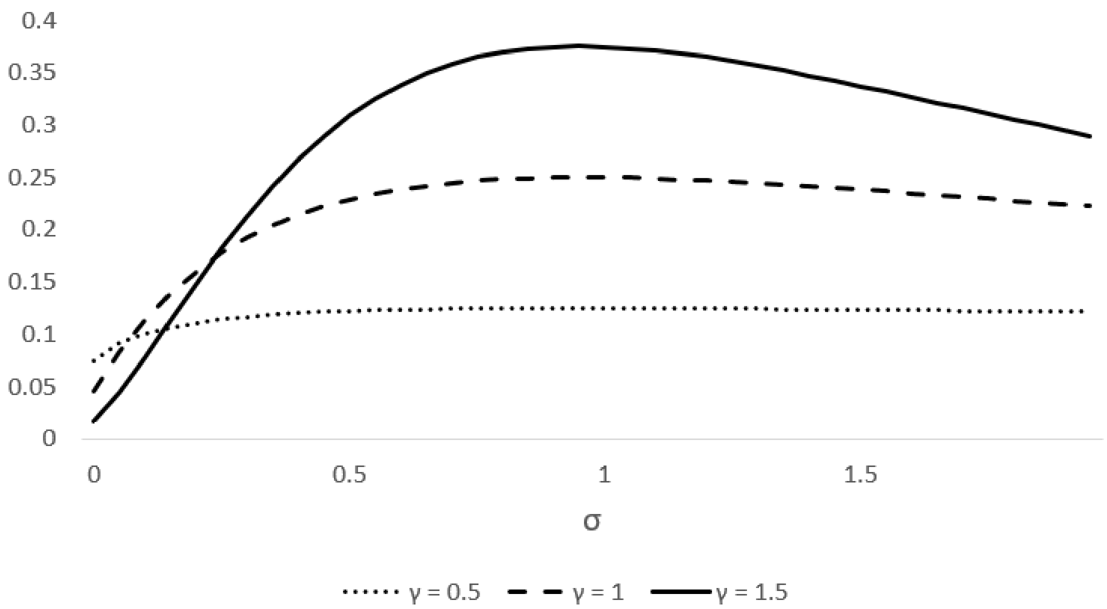


Figure 3: Winning Percentages

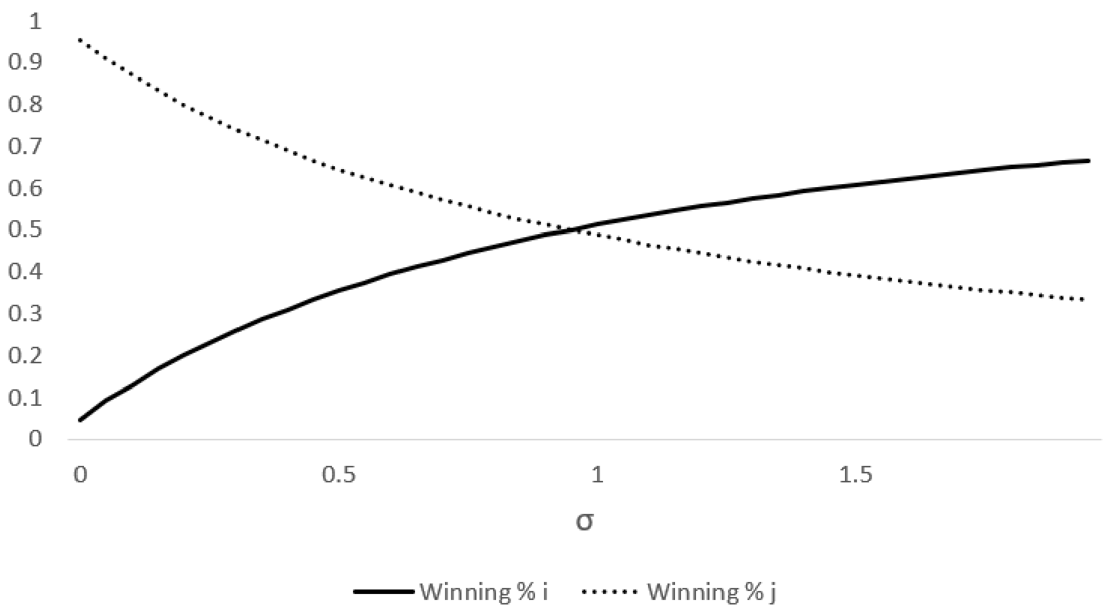


Figure 4: Team profits

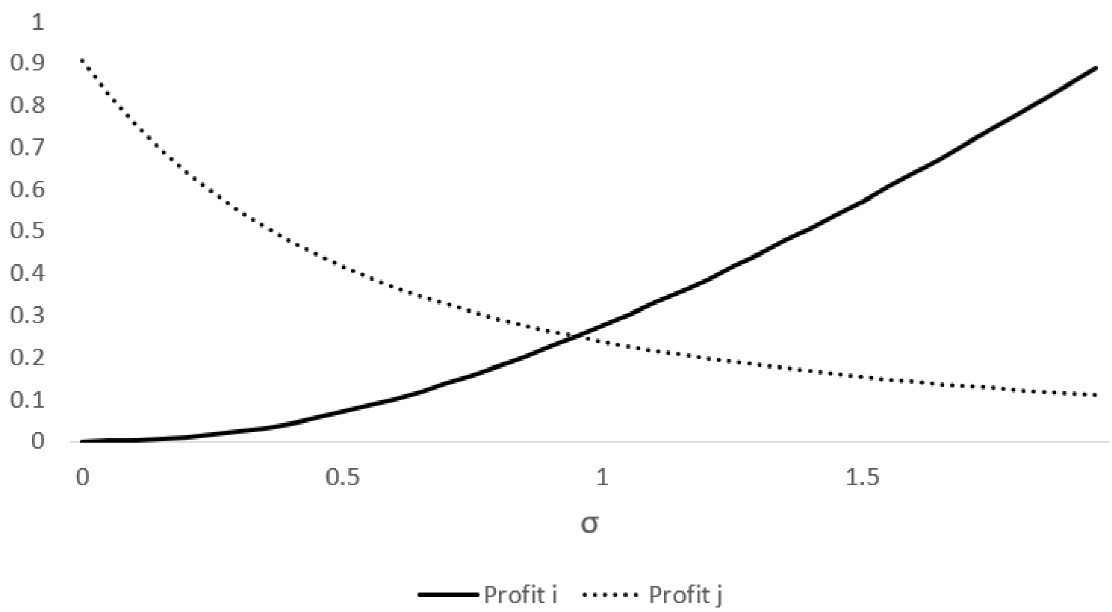


Figure 5: Total League Profit

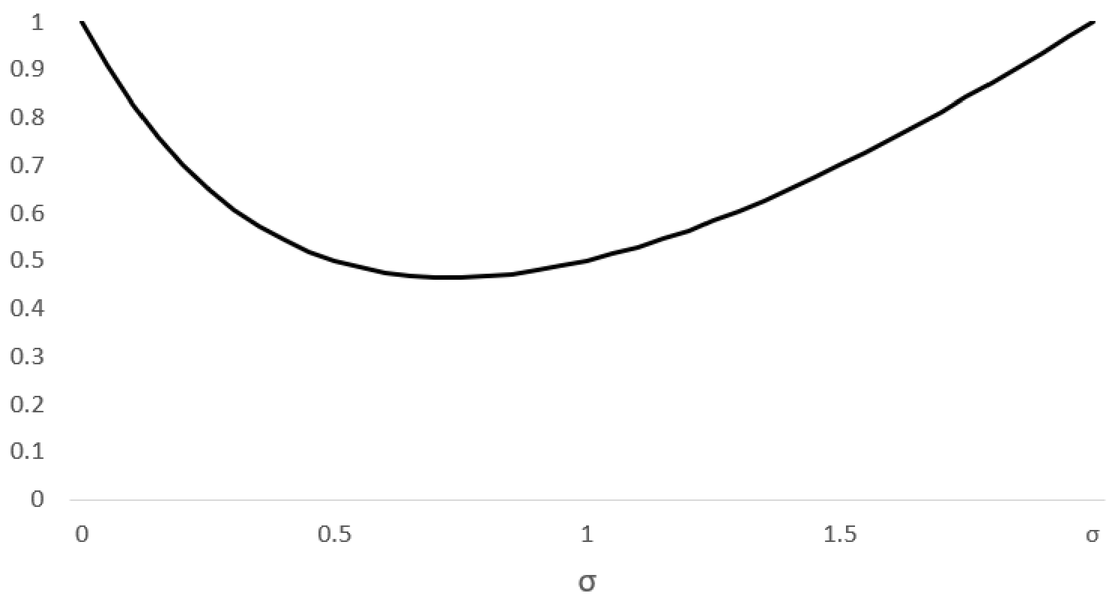


Figure 6: League Investments

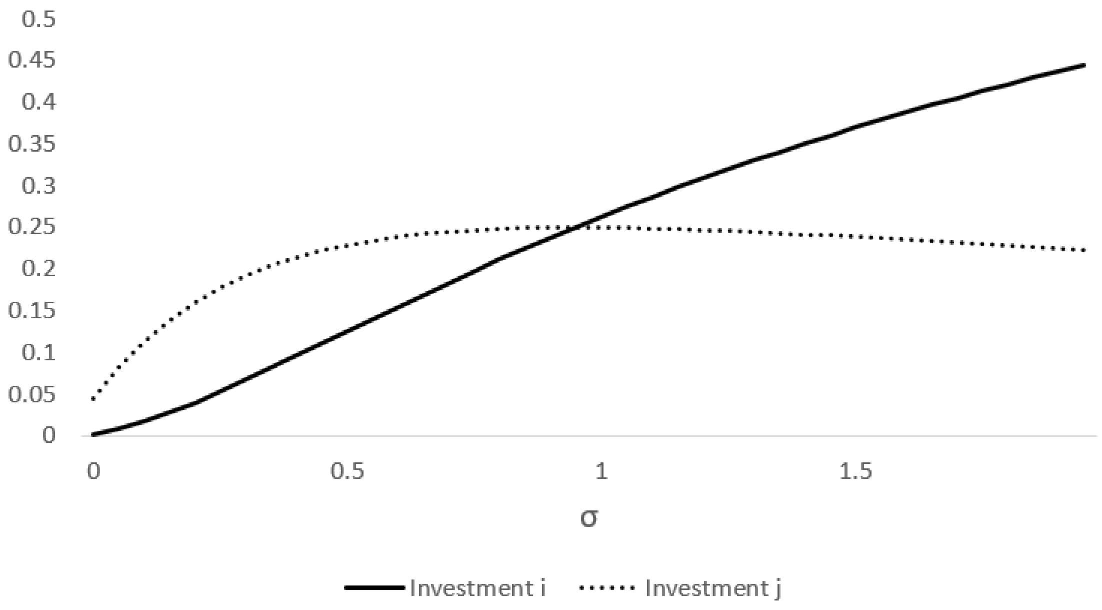
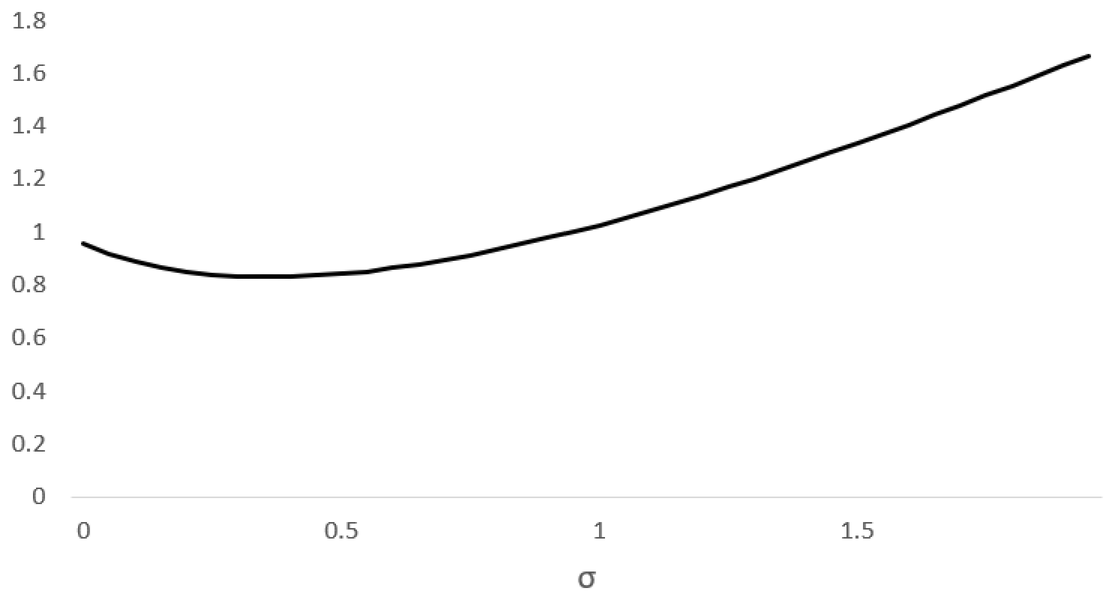


Figure 7: Total League Revenues



2 The Economics of Food Courts

2.1 Introduction

Demand for food inside food courts is somewhat unique in that consumers typically arrive knowing they will purchase a meal, vendors then compete for consumers once they have already arrived. This implies that aggregate demand is largely fixed. That is, consumers purchase a set amount of meals. The consumer's decision to patronize a food court could be exogenous or dependent upon investments of the vendors. For example, travelers may purchase a fixed number of meals at an airport, but most travelers do not choose an airport based on the food selections. In this case, vendors are competing against each other for a fixed number of customers. However, in other circumstances a consumer's decision to patronize the food court could also depend upon the aggregate or collective reputation of the food court. This can be the case if the purpose of the food court is to attract a variety of consumers. Meaning, some food courts are the consumer's destination. Under this scenario of collective reputation, where the group of vendors creates a reputation, there may be both positive and negative externalities from the firm's quality choice. If one vendor in the food court increases their quality, this will take away demand for other restaurants if demand is fixed. On the other hand, a higher quality will also increase the collective reputation of the entire food court. This paper analyzes these quality decisions using contest success functions (CSFs) under various scenarios and different types of food courts.

Food courts or food halls take many forms. Often, food courts are a way of offering various types of food to captive consumers. In this case, consumers have little choice in consuming food at the food court, but they still choose which vendor to patronize within the food court. Airports and shopping malls typically have various firms offering food, and overall demand is fixed to the extent that eating elsewhere is prohibitively inconvenient. In this example, firms can differentiate by locating apart from competing firms or offering a type of food different from other firms. Vendors can compete with each other in various ways. Besides various quality choices, some vendors may choose to offer a broad or popular menu, while others may choose more niche markets. Thus, vendors can differentiate themselves both vertically and horizontally. Also, firms may be heterogeneous in profitability per customer.

Some food courts rely on consumers coming specifically to the food court due to the quality of food. In this scenario, the food court is the destination itself. For example, De Foodhallen in Amsterdam or Naschmarkt in Vienna create unique markets where consumers can go to find a variety of choices. Beer fests and other events may be similar in that demand depends on the quality of the vendors. In this example aggregate demand depends upon the average quality, which then creates a collective reputation for the food court. This implies two stages. In the first stage aggregate demand for the food court is determined by the collective reputation, and in the second stage, vendors compete for consumers like they would in an airport or shopping mall.

Different types of food courts may have competing incentives. If aggregate demand is completely fixed, there is an incentive for the food court to lower investment costs since an increase in quality simply takes consumers away from competitors. In the same way a cartel wants to maintain high prices, the food court would want to restrict costs. However, if profitability varies for each vendor, this could also change the incentives. Furthermore, a collective reputation for the food court creates an incentive to foster investment since a high quality may bring in more consumers.

This paper first models a scenario with one stage where demand is fixed and vendors invest in quality. Next, revenue sharing is analyzed as a potential way to decrease competition. Then, creating more or less product differentiation between vendors is shown to be able to also change the amount of competition between vendors. Finally, the situation where demand is dependent upon the collective reputation of the food court is analyzed.

2.2 Literature Review

Many studies have looked at the quality of food and restaurants. However, "quality" can come in many forms for restaurants and vendors, and there may be many dimensions that consumers care about (Markovic et al., 2011; Azim et al., 2014; Almohaimmeed, 2017). Whatever consumers perceive as quality, investment into quality can be heavily dependent upon incentives and reputation. For example, Using restaurant data Jin and Leslie (2009) shows that the level of hygiene is dependent upon reputational effects. Using a general view of quality, Blair and Kaserman (1994) theoretically show that incentives for firms such as franchises can cause inefficiencies. With an endogenous quality decision by each firm, the franchisee has little incentive to produce the efficient level of quality. This shows that the ownership structure matters and quality investment decisions are different depending upon whether the firms are competing or cooperating. Similarly, Winfree and McCluskey (2005) show that not receiving the full benefit of a quality investment can create inefficiencies due to collective reputation effects.

Food courts are often associated with travel. Others have noted that with travel or tourism destinations there is an incentive for firms to coordinate due to the substitutability of goods. Andergassen et al. (2013) models the optimal development strategy of a tourism destination by analyzing two key economic features; the long-term choice of whether to invest in the enhancing of natural and/or cultural resources or to increase the degree of sophistication of the product, and the short-term choice of whether or not to implement price coordination among local firms. Andergassen et al.

(2017) expands upon this by evaluating alternative patterns of strategic interaction among destinations. Competing agents can either play cooperative or non-cooperative strategies in terms of price coordination and investment in resources, with the theoretical outcome of the different firm choices being parsed out. The models presented in these papers ties to our analysis of food courts, as they are evaluating competitive decisions made by separate firms and whether or not they will compete or coordinate with one another.

Also examining competition and the location of firms, Konishi (2005) examines placing stores that sell similar products near each other, which presents a trade-off between attracting more consumers and competing with each other for those consumers. Similarly, Bester (1989) and Dudey (1990) examine firms' location decisions and prices. These models typically include a cost for consumers if they have to travel between firms, which is similar to having a food court that can attract consumers, but then must compete for those consumers once they are there. However, our model is different from these models in that firms choose their quality investments and there are a fixed number of sales once the number of consumers has been determined.

The nature of a food court is what makes modeling food courts with CSFs useful. Once consumers arrive at the food court, they decide which vendor to patronize, which is a type of contest. Research has used various paradigms for consumer choices in food courts including decision trees (Bozkir and Sezer, 2011), experiments using behavior economics (Just and Wansink, 2009) and consumer surveys (Tan and Arcaya, 2020). These studies find that food type and location matter in consumer decisions. The benefit of using a CSF is that it can be altered so that different contests can be analyzed. For example, how do vendor incentives change as vendor location and/or horizontal differentiation changes?

In Corchón (2007) a theoretical framework of a contest is presented and summarized. The survey goes on to provide an overview of many of the key features of a contest including: symmetric contests, asymmetric contests, social welfare under rent-seeking, and the design of the optimal contest. Further designs of contests are presented in Alcalde and Dahm (2007) in which the "serial contest" is established by building on the most desirable features of Tullock's proposal (relative effort differences) and Hirshleifer's proposal (absolute effort differences). In the serial contest, win probabilities depend on percentage markups of effort. These papers clarify how CSFs can be understood and used to evaluate different contest constructions. We build on these papers by analyzing various asymmetric contests using relative investment differences.

Additional research explores the role of effort as it pertains to the model and outcomes of contests. In Sheremeta (2011), the performance of four simultaneous lottery contests (a grand contest, two multi-prize settings, and a contest which consists of two sub-contests) are compared. This work shows that the grand contest generates the highest effort levels and in the multi-prize settings, equal prizes produce lower efforts than unequal prizes. Münster (2009) models an imperfectly discriminating contest, in which contestants meet repeatedly. The model shows that if effort is observable, a ratchet effect in contests may be induced. In our paper, quality investments of vendors are analogous to players' effort.

Much of the CSF literature focuses on payoff structures. In our context, this is represented by the profitability of gaining a new customer. While the literature of incentivizing people in a contest through various payoffs is quite old (Galton, 1902; Glazer and Hassin, 1988), this paper takes the payoff structure as exogenous. In other words, the food court does not decide the profitability of the vendors. Rather, this paper assumes the contest could be changed, as in Runkel (2006). The contest could be determined by a contest designer, in this case the food court. Our paper uses a

Tullock (1980) CSF, which is described in detail in Skaperdas (1996).

As Corchón and Dahm (2010) note, a CSF can be used to create a spatial model, as found in the seminal paper by Hotelling (1929). This implies that a CSF can be used for modeling product differentiation in either geographic space or product space. Similarly, Bar-Isaac et al. (2021) analyze the case of firms choosing product differentiation along a Salop (1979) circle. They find that market structure can determine how specific or broad of a product a firm may want. For example, search costs and market structure may determine whether a restaurant offers a general menu or a very specific cuisine. Using Hotelling's boardwalk model, having the vendors in the middle of the boardwalk creates virtually identical products while having the vendors at the ends of the boardwalk creates different products. Similarly, this can be done in product space. For example, if the food court has two vendors that serve food with a medium level of spiciness, then they are maximizing competition with each other. However, if one vendor agrees to produce non-spicy food while the other agrees to produce very spicy food, there is less competition between the two.

If vendors are homogeneous, then the food court maximizes joint profits by placing the vendors at the extremes (at each end of the boardwalk, or opposite types of food). However, if the contest is asymmetric and vendors receive different payoffs, the location of the vendors is not obvious. The food court would want more consumers at a vendor with a higher payoff, but would also want to minimize competition and quality investments. If the food court has a collective reputation and aggregate demand is not fixed, this complicates the contest further.

2.3 Theoretical Model

This section examines the quality choices made by vendors in a food court. Vendors compete with each other for consumers with their investments in quality. The model does not focus on price competition for a few reasons. First, adding a price variable often limits the parameters in these types of models due to the non-existence of a Nash Equilibrium (d'Aspremont et al., 1979). Second, adding a price mechanism to the model may distract from the focus on the investment incentives for firms. Third, food court vendors are often franchisees that have prices that are limited and/or predetermined by the franchise, while investments are not as limited.

It is assumed that the food court's objective is to maximize joint profits of the vendors and it may be able to increase profits by changing the contest. If the food court sells vendor space equal to profits, or if the food court owns a stake in the vendors collectively, then they may be maximizing joint profits of all the vendors. However, quality investments are made by each individual vendor.

It is initially assumed that aggregate demand is fixed such that $\sum_{i=1}^{N} q_i = Q$, where q_i is the quantity sold by firm i. In this case, the number of consumers and their quantity does not change, but they do choose which vendor to patronize, so the individual firm's sales are not fixed. First, a general model is created with N vendors showing general incentives and is more aligned with previous research on CSFs.[2] Vendors make simultaneous investments into quality, k_i.[3] Once investments are chosen, consumers then choose which vendor to purchase food from. These costs are long term investment costs, not per unit costs. Therefore, vendors face a contest success function which determines their quantity. For simplicity, the Tullock (1980) or ratio CSF, is used. Quantity depends upon investments such that

$$q_i = Q \frac{k_i^{\gamma}}{\sum_{j=1}^{N} k_j^{\gamma}} \tag{9}$$

[2]This model is simplified to two firms and linear revenue curves to show the effects of policies.

[3]We primarily think of k as a quality investment, but there may be other mechanisms to attract consumers. For example, these could be thought of as advertising expenditures.

where vendor i's investment is given by $k_i \in [0, \infty)$. γ can be thought of as the degree of product differentiation.[4] It can be a proxy for geographic location or product space, however, it must be the case that all firms are equally distant from each other.[5] If γ is low, then investments have little impact on success. For example, if the vendors are far apart, the consumer's choice will depend less upon investments and consumers will be relatively evenly split up between the vendors. In this case, there is little competition between vendors. If $\gamma = 0$ then restaurant investments have no impact on quantity. As γ increases quantity becomes more variable. Given this functional form, quality investments increase the firm's quantity, $\frac{\partial q_i}{\partial k_i} > 0$, quantity decreases when the opposing restaurant increases investment, $\frac{\partial q_i}{\partial k_j} < 0$, and the cross-partial derivative is positive for the restaurant that has invested more in quality, $\frac{\partial^2 q_i}{\partial k_i \partial k_j} > 0$ if $k_i > k_j$.

Therefore, vendor i has an objective function given by,

$$\pi_i = f_i \left(Q \frac{k_i^\gamma}{\sum_{j=1}^{N} k_j^\gamma} \right) - k_i \tag{10}$$

where f is the payoff function that determines the benefit of winning the contest and is unique for each vendor. In other words, vendors may be heterogeneous in their payoff per customer. The complementary slackness conditions are given by,

$$k_i \geq 0, f_i' Q \frac{\gamma k_i^{\gamma-1} \sum_{\substack{j=1 \\ j \neq i}}^{N} k_j^\gamma}{\left[\sum_{j=1}^{N} k_j^\gamma \right]^2} - 1 \leq 0, c.s. \tag{11}$$

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[4]γ is assumed to be nonzero, but has an upper bound, which depends upon the number of vendors. For example, Baye et al. (1994) shows that if $\gamma > 2$ then there may be mixed solutions when $N = 2$.

[5]This may be problematic if there are even a few vendors. This is why most of the models focuses on the case with two firms, but a more general model is presented to illustrate some incentives.

If all firms are at an interior solution, the following equilibrium condition is given,

$$\frac{k_i}{f_i'} = \frac{k_j}{f_j'}, \forall_{i,j} \tag{12}$$

Therefore, the optimal investment for vendor i is given by,

$$k_i = \frac{\gamma f_i' \sum\limits_{\substack{j=1 \\ j \neq i}}^{N} \frac{f_j'^{\gamma}}{f_i'^{\gamma}}}{\left[\sum\limits_{j=1}^{N} \frac{f_j'^{\gamma}}{f_i'^{\gamma}} \right]^2} \tag{13}$$

and the optimal quantity for vendor i is given by,

$$q_i = Q \frac{\left[\sum\limits_{\substack{j=1 \\ j \neq i}}^{N} \frac{f_j'^{\gamma}}{f_i'^{\gamma-1}} \right]^{\gamma}}{\sum\limits_{l=1}^{N} \left[\sum\limits_{\substack{j=1 \\ j \neq l}}^{N} \frac{f_j'^{\gamma}}{f_l'^{\gamma-1}} \right]^{\gamma}} \tag{14}$$

In the case of the food court, their objective is to maximize joint profits. If the food court generates profits as a linear function of joint profits of the vendors, then their objective is to maximize joint profits. In this case, the overall profitability of the food court is equal to the sum of all profits, therefore, the food court's objective may be given by,

$$\Pi = \sum_{i=1}^{N} f_i \left(\frac{h(k_i)}{\sum\limits_{j=1}^{N} h(k_j)} \right) - \sum_{i=1}^{N} k_i \tag{15}$$

and the change in joint profits from an increase in vendor i's investment is given by,

$$\frac{\partial \Pi}{\partial k_i} = f_i' \frac{h'(k_i)\sum\limits_{\substack{j=1\\ j\neq i}}^{N} h(k_j)}{\left[\sum\limits_{j=1}^{N} h(k_j)\right]^2} - \sum_{\substack{j=1\\ j\neq i}}^{N} f_j' \frac{h'(k_i)h(k_j)}{\left[\sum\limits_{j=1}^{N} h(k_j)\right]^2} - 1 = \frac{\partial \pi_i}{\partial k_i} - \sum_{\substack{j=1\\ j\neq i}}^{N} f_j' \frac{h'(k_i)h(k_j)}{\left[\sum\limits_{j=1}^{N} h(k_j)\right]^2} \quad (16)$$

Since $\frac{\partial \pi_i}{\partial k_i} > \frac{\partial \Pi_i}{\partial k_i}$, there is an incentive for the food court to reduce investments. In other words, the optimal investments for the vendors are higher than what is optimal for the food court. Again, this is because when one vendor invests more, it takes away customers from the other firms in the food court. Therefore, the food court has an incentive to collude or set policies that reduce investment if they are able to do so. A similar strategy would be for the food court to design a contest that reduces the incentive to invest.

Also important, is that food courts may have a preference for which vendor the consumer chooses. If $f_i' \neq f_j'$, then aggregate revenues/payoffs change since the quantity changes for vendors when investments change. Although it is assumed that the food court only controls the CSF and not investments, a food court would unequivocally prefer for vendors with small payoffs to reduce their investment as that in turn reduces the quantity for vendors with a small payoff.[6] The same cannot be said of vendors with large payoffs. Thus, the optimal CSF depends upon the heterogeneity of the payoffs and the marginal value of investments in quality.

The incentives are more easily shown if we assume only two vendors and a linear revenue function, so that $\pi_i = \sigma_i \left(Q \frac{k_i^\gamma}{k_i^\gamma + k_j^\gamma} \right) - k_i$. In that case, the equilibrium values are given by,

[6] If a food court maximized joint profits by choosing all investment levels, the vendor with the smallest payoff would always have an investment equal to zero.

$$k_i = Q\frac{\gamma\sigma_i^{\gamma+1}\sigma_j^{\gamma}}{\left(\sigma_i^{\gamma}+\sigma_j^{\gamma}\right)^2} \tag{17a}$$

$$q_i = Q\frac{\sigma_i^{\gamma}}{\sigma_j^{\gamma}+\sigma_i^{\gamma}} \tag{17b}$$

$$\pi_i = Q\frac{\sigma_i^{\gamma+1}}{\sigma_j^{\gamma}+\sigma_i^{\gamma}}\left(1-\frac{\gamma\sigma_j^{\gamma}}{\sigma_i^{\gamma}+\sigma_j^{\gamma}}\right) \tag{17c}$$

$$\Pi = \pi_i + \pi_j = \frac{Q}{\sigma_j^{\gamma}+\sigma_i^{\gamma}}\left(\sigma_i^{\gamma+1}+\sigma_j^{\gamma+1}-\frac{\gamma\left(\sigma_i^{\gamma+1}\sigma_j^{\gamma}+\sigma_j^{\gamma+1}\sigma_i^{\gamma}\right)}{\sigma_i^{\gamma}+\sigma_j^{\gamma}}\right) \tag{17d}$$

This is the equilibrium aggregate profit and not the maximized aggregate profit. There is an incentive for the food court to have the vendors reduce investment and have all the consumers go to the vendor with the largest payoff. So, they do not want a firm with a small payoff to have any investment. Next, various changes in the contest are analyzed to see the effects.

2.4 Revenue Sharing

This section analyzes revenue sharing where a percentage of revenues are given to the other vendor. If the two vendors share revenues, there is a clear incentive to decrease investments since they do not fully receive the benefits of their investments. In this case, firm i's objective function is given by,

$$\pi_i = (1-\alpha)\sigma_i Q\frac{k_i^{\gamma}}{k_i^{\gamma}+k_j^{\gamma}} + \alpha\sigma_j\frac{k_j^{\gamma}}{k_i^{\gamma}+k_j^{\gamma}} - k_i \tag{18}$$

where α is the amount of revenue that is shared and given to the other vendor. In this case, the complementary slackness conditions are given by,

$$k_i \geq 0, \left[\sigma_i(1-\alpha) - \sigma_j\alpha\right] \sigma_i Q \frac{\gamma k_i^\gamma}{(k_i^\gamma + k_j^\gamma)^2} - 1 \leq 0, c.s. \tag{19}$$

In the event of a non-corner solution, the equilibrium quality is given by,

$$k_i = Q\gamma \frac{\left[\sigma_i(1-\alpha) - \sigma_j\alpha\right]^{\gamma+1} \left[\sigma_j(1-\alpha) - \sigma_i\alpha\right]^\gamma}{\left(\left[\sigma_i(1-\alpha) - \sigma_j\alpha\right]^\gamma + \left[\sigma_j(1-\alpha) - \sigma_i\alpha\right]^\gamma\right)^2} \tag{20}$$

and the equilibrium quantity is given by,

$$q_i = Q \frac{\left[\sigma_i(1-\alpha) - \sigma_j\alpha\right]^\gamma}{\left[\sigma_i(1-\alpha) - \sigma_j\alpha\right]^\gamma + \left[\sigma_j(1-\alpha) - \sigma_i\alpha\right]^\gamma} \tag{21}$$

Perhaps unintuitively, this shows that revenue sharing leads to more customers for the vendor with the higher revenue. This implies that sharing revenue certainly leads to an increase in profitability because not only does it lead to an decrease in investments, it also leads to more total revenue. The profitability of the larger restaurant is unclear since the revenue and costs both decrease. However, if the restaurants are of equal size, the only effect is lower investments in quality and therefore higher profitability.

Figure 1 shows the various equilibria if there are various degrees of revenue sharing. Specifically, when σ_i equals 1, 3, or 5 and σ_j and Q are assumed to be equal to 1. It is also assumed that each vendor will have some positive investments so that the range for α is such that $\sigma_j(1-\alpha)-\sigma_i\alpha > 0$. The first panel shows that an increase in revenue sharing decreases investments for firm i, and the response is more dramatic if σ is larger. Revenue sharing also decreases investment for vendor j. Figure 8 further shows that under these assumptions, profits increase for both firms as revenue sharing increases. So, even though the firm with the larger payoff has net losses in terms of sharing revenue, this effect is smaller than the decrease in investments under these parameters. Since profits increase for both firms, total profits also increase. Also, as revenue sharing increases, the firm with the higher payoff receives more customers.

2.5 Horizontal Product Differentiation

As previously stated, γ can be a proxy for product differentiation, which could either be in product space or actual location. For example, if vendors are right next to each other, then there is more competition due to quality. If they are far apart, then quantity is less variable. If γ is changed, then the effect of quality investment on quantity is also changed. The change in the marginal effect of quality from a change in γ is given by,

$$\frac{\partial^2 q_i}{\partial k_i \partial \gamma} = \frac{Q k_i^{\gamma-1} k_j^{\gamma}}{\left(k_i^{\gamma} + k_j^{\gamma}\right)^3} \left[k_i^{\gamma} + k_j^{\gamma} + \gamma \left(k_i^{\gamma} - k_j^{\gamma}\right) \left(ln(k_j) - ln(k_i)\right)\right] \tag{22}$$

This equation cannot be signed, therefore it is not clear if product differentiation increases or decreases the marginal benefit of investment. If vendors are relatively equal in payoffs, then increasing γ will increase the marginal benefit of quality, therefore quality investment will increase. However, if investment is disparate enough between the two vendors, increasing γ will decrease the marginal benefit of quality and talent investment will decrease. The effect of changing the degree of product differentiation on aggregate profits is given by,

$$\frac{d\Pi}{d\gamma} = \frac{Q}{\sigma_i^{\gamma} + \sigma_j^{\gamma}} \left[ln(\sigma_i)\sigma_i^{\gamma+1} + ln(\sigma_j)\sigma_j^{\gamma+1} - 1 + \frac{ln(\sigma_i)\sigma_i^{\gamma} + ln(\sigma_j)\sigma_j^{\gamma}}{\sigma_i^{\gamma} + \sigma_j^{\gamma}}\right] \tag{23}$$

which again, cannot be signed.

Investments, percentage of customers, and vendor profits for various levels of γ are shown in Figure 9. Again, it is assumed that σ_i equals 1, 3, or 5, $\sigma_j = 1$ and $Q = 1$. The figure shows that if the ratio of the payoffs is small, an increase in γ causes both vendors to increase their investments. However, if one vendor has a much larger payoff per customer than the other vendor, then both vendors eventually decrease their investment as γ increases. This implies that at some point, the contest becomes more certain and the marginal impact of investment decreases. In other words, if γ is large and one vendor has a much larger payoff, then investments into quality are less valuable since a large majority of customers will choose the vendor with the high payoff. If the payoffs are relatively equal, then vendor profits are maximized when $q_i = \frac{Q}{2}$ and γ is low. If payoffs are different enough though, then the food court will want more centralized locations to ensure the vendor with the higher payoff gets more customers. One interesting point is that for some levels of σ, there exists a location that minimizes profits and is a non corner solution. Therefore, either extreme of competitive location is not minimizing food court profits for those unique levels of σ.

There are many other reasons, not considered here, that might be factored into location decisions for vendors. Having all vendors at the same location might produce cost savings, or there may be benefits in having variety in one location. Alternatively, it may be more convenient for consumers if the vendors are spread out so there is less distance from consumers. However, this section shows that differentiation in either location or product space changes the dynamic of competition. If the vendors are more similar, then quality investment play a more important role.

2.6 Collective Reputation

This section allows for varying aggregate demand in the food court. This may be true for food courts that are the main attraction for consumers. So, this may not be the case of an airport where consumers are there for other reasons, but rather this situation explains certain festivals or food courts that are designed to bring consumers there specifically for the food offered. In this situation, quality investments have two effects. First, the aggregate demand for the food court is determined by the average quality. Second, based on quality, vendors compete for a fixed number of consumers. In this case it is not obvious whether increasing quality produces a positive or negative externality for other vendors. A high quality vendor brings more consumers to the food court, but also takes most of the consumers once they are there.

It is assumed that demand for the food court depends on a collective reputation, which is equal to the aggregate quality level such that, $R = k_i + k_j$. In this case, the number of customers for the food court depends upon their quality *and* the quality level of the other vendors in the food court. Since aggregate demand is not fixed, it is not obvious if a higher or lower investment level is optimal for the food court. For tractability, we let $\gamma = 1$ and $Q = R^{\phi}$. To ensure concavity, ϕ must be less than 1. However, to ensure that each firm makes a nonzero investment, it must be the case that $\phi < \frac{\sigma_j}{\sigma_i}$ where $\sigma_j < \sigma_i$, therefore this assumption is made. Each vendor's profit function is given by,

$$\pi_i = \sigma_i (k_i + k_j)^{\phi} \frac{k_i}{k_i + k_j} - k_i \tag{24}$$

If each vendor maximizes its profits, the investment decision must satisfy the following complementary slackness condition,

$$k_i \geq 0, \sigma_i \left[(k_i + k_j)^{\phi - 1} - k_i (1 - \phi)(k_i + k_j)^{\phi - 2} \right] - 1 \leq 0, c.s. \tag{25}$$

This means that the equilibrium values are given by,

$$k_i = \frac{\sigma_i - \sigma_j \phi}{(1 - \phi)(\sigma_i + \sigma_j)} \left[\frac{\sigma_i \sigma_j (1 + \phi)}{\sigma_i + \sigma_j} \right]^{\frac{1}{1 - \phi}} \tag{26a}$$

$$q_i = \frac{\sigma_i - \sigma_j \phi}{1 - \phi} \left[\sigma_i \sigma_j (1 + \phi) \right]^{\frac{\phi}{1 - \phi}} \left(\sigma_i + \sigma_j \right)^{\frac{-1}{1 - \phi}} \tag{26b}$$

$$\pi_i = \frac{\sigma_i - \sigma_j\phi}{1-\phi}\left[\frac{\sigma_i\sigma_j(1+\phi)}{\sigma_i+\sigma_j}\right]^{\frac{1}{1-\phi}}\left[\frac{\sigma_i}{\sigma_i\sigma_j(1+\phi)} - \left(\sigma_i+\sigma_j\right)^{-1}\right] \tag{26c}$$

$$\Pi = \pi_i + \pi_j = \frac{\left[\sigma_i\sigma_j(1+\phi)\right]^{\frac{\phi}{1-\phi}}}{1-\phi}\left(\sigma_i+\sigma_j\right)^{\frac{-2+\phi}{1-\phi}}\left[\sigma_i(\sigma_i-\sigma_j\phi)^2 + \sigma_j(\sigma_j-\sigma_i\phi)^2\right] \tag{26d}$$

This is compared with the optimal investments for the food court. Investment by firm i has the following marginal impact on joint profits,

$$\frac{d\Pi}{dk_i} = \sigma_i\left[(k_i+k_j)^{\phi-1} - k_i(1-\phi)(k_i+k_j)^{\phi-2}\right] - \sigma_j k_j(1-\phi)(k_i+k_j)^{\phi-2} - 1 \tag{27}$$

This shows that $\frac{d\Pi}{dk_i} < \frac{d\pi_i}{dk_i}$ and so firms will still over invest relative to the optimal investments that maximizes joint profits when $\gamma = 1$. However, if we take a counter example where $\gamma = 0$, so that all vendors receive an equal share of consumers, this reverts to a basic collective reputation model where firms under invest because vendors do not receive the full benefit of their investment. Therefore, some level of competition within vendors is required for firms to over invest in equilibrium.

To illustrate this, we set $\sigma_i = \sigma_j$ and allow γ to vary. In this scenario,

$$\pi_i = \sigma(k_i+k_j)^{\phi}\frac{k_i^{\gamma}}{k_i^{\gamma}+k_j^{\gamma}} - k_i \tag{28}$$

and since $\sigma_i = \sigma_j$ the firms are symmetrical, so the complementary slackness condition is given by,

$$k_i \geq 0, \frac{\phi+\gamma}{2}\sigma(2k)^{\phi-1} - 1 \leq 0, c.s. \tag{29}$$

The joint profits are given by,

$$\Pi = \pi_i + \pi_j = \sigma(k_i+k_j)^{\phi} - k_i - k_j \tag{30}$$

and investment by firm i has the following marginal impact on joint profits,

$$\frac{d\Pi}{dk_i} = \phi\sigma(2k)^{\phi-1} - 1 \tag{31}$$

Note that $\frac{d\pi_i}{dk_i} = \frac{d\Pi}{dk_i}$ if $\phi = \gamma$. If $\phi > \gamma$ then firms will under invest relative to joint profits, but if $\phi < \gamma$ then firms will over invest relative to joint profits. This shows that if consumers attend the food court due to the collective reputation and there is little competition between vendors, then the food court has an incentive to get vendors to invest more in quality. On the other hand, if aggregate consumption at the food court is not dependent upon quality investments and vendors compete with each other for consumers, then the food court has an incentive to decrease quality investments.

2.7 Conclusion

This paper shows that vendors in food courts can have an incentive to over invest into quality relative to the optimal investment for joint profits for the entire food court. Possible solutions to this exist by sharing revenues or increasing product differentiation. Both of these cause a decrease in quality investment. In the case of revenue sharing, vendors make investment decisions based more on aggregate revenues than the individual vendor's revenues. Perhaps counter intuitively, if the vendors share revenue, the vendor with the larger payoff receives even more customers.

In the case of product differentiation, creating more differentiation causes less competition between vendors. This might be done by providing very different products or locating vendors in different places. However, if vendors are heterogeneous in the profitability per customer, then increasing product differentiation may not increase aggregate profits because of the decreased revenues this creates.

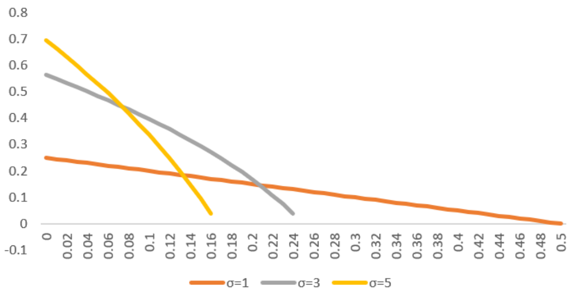
In the situation where the food court has a collective reputation, firms still may over invest in quality, depending upon the competition between vendors. Using an often used contest success function[7], quality investment creates more competition within the food court relative to gaining more customers at the food court, so vendors still over invest. However, in the absence of competition between vendors, they will under invest in quality.

Of course, there may be other incentives for food courts that are not contained in the model. Some food courts may focus more on consumer surplus. For example, perhaps an airport sees value in providing high quality vendors to consumers. In other words, high quality vendors may be seen as an amenity to a larger market. Some food courts may also be seen as a way to bring consumers to a location to foster demand for ancillary goods. Whatever the motivation may be, there are spillover effects from food courts that may cause incorrect incentives in quality investment.

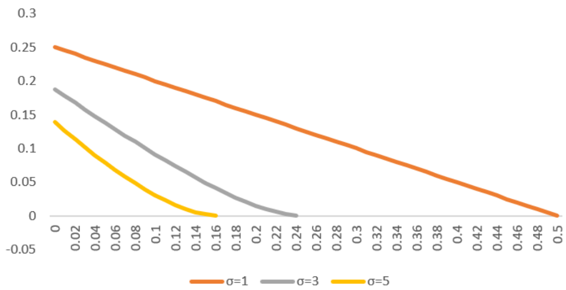
[7] A Tullock CSF with an exponent equal to one.

Figure 8: The effects of changing revenue sharing (α)

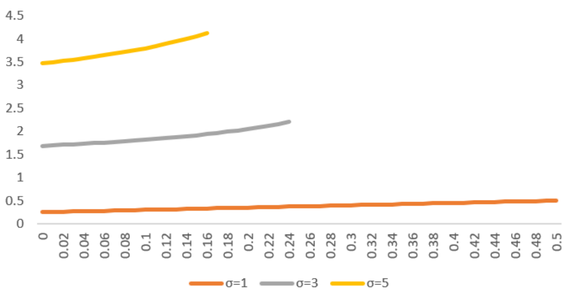
(a) Investment of vendor i



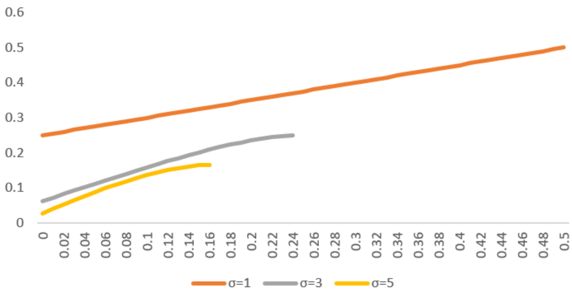
(b) Investment of vendor j



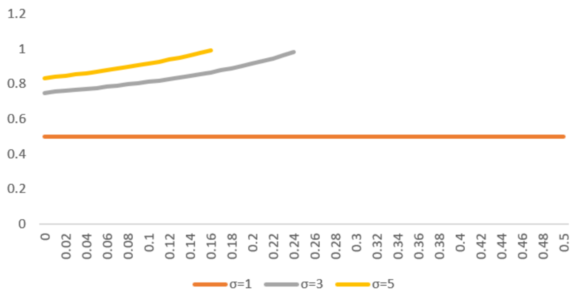
(c) Profit of vendor i



(d) Profit of vendor j



(e) Percentage of customers to vendor i



(f) Total profit

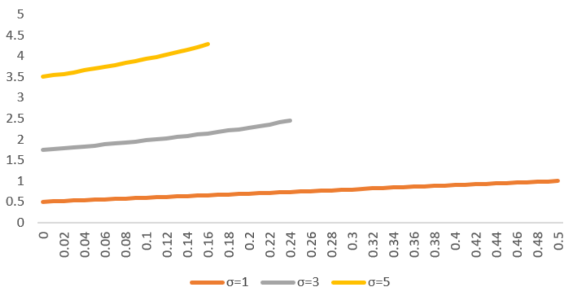
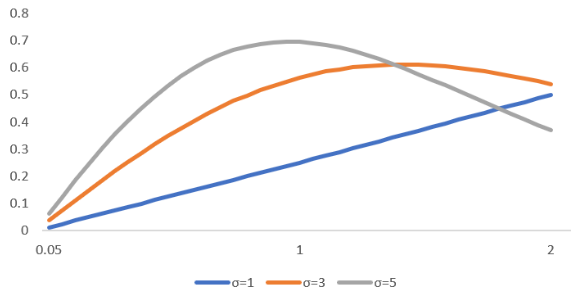
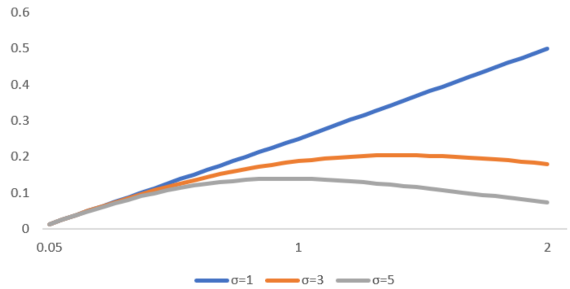


Figure 9: The effects of changing product differentiation (γ)

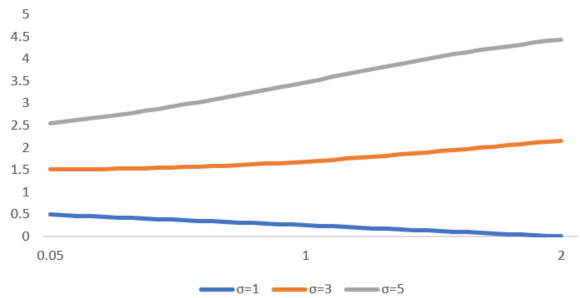
(a) Investment of vendor i



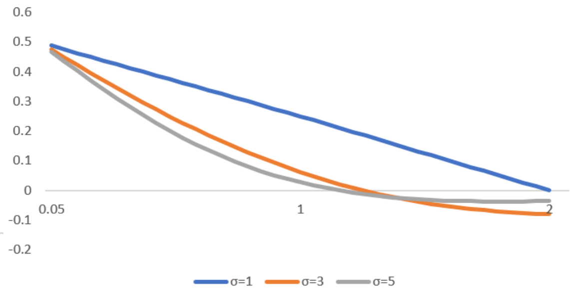
(b) Investment of vendor j



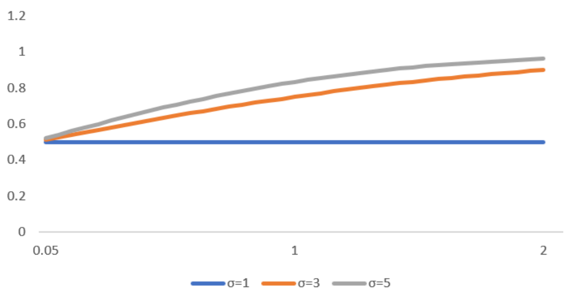
(c) Profit of vendor i



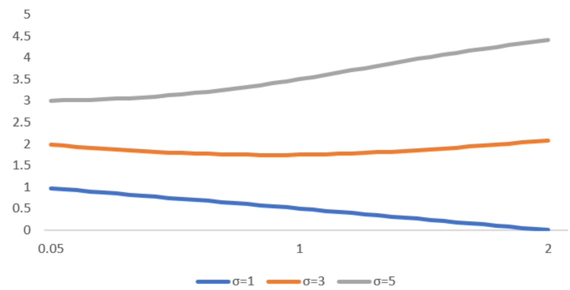
(d) Profit of vendor j



(e) Percentage of customers to vendor i



(f) Total profit



3 Consumer Substitution of Vodka

3.1 Introduction

Consumer demand has long served as the driving motivation for economic analysis and research with consumer demand for alcohol being no exception. However, it is often the case that alcohol demand is most often modeled under one of three categories: beer, wine, or liquor. While this base analysis may seem intuitive on the surface, a problem exists in that it assumes that the market for all liquor (outside of beer and wine) is the same and all alcohol types can be examined as one market. The research presented in this paper questions this approach, believing that each individual liquor type is entirely unique and existing as its own market to be analysed. Under this assumption, each individual liquor type can be modeled to explore how consumption of that liquor is impacted by changes in its own price, price of other alcohol, income, population, employment, etc; effectively defining the market that exists for a specific type of liquor.

In this vein, the research presented focuses on the market for different classifications of vodka. A key assumption to be explored throughout this paper is that the consumers of individual vodka are substituting and complementing their vodka consumption in a distinct manner as these consumers have their own idiosyncratic tastes and preferences that motivate how and how much vodka they consume. Naturally, this also assumes that consumers of a specific type of vodka are not only different from consumers of a different type of vodka but also that their consumption behavior is not identical to that of any alcohol other than vodka such as: whiskey, rum, tequila, or any other definable alcohol type. With each liquor classification existing as an especial market.

In order to explore the behavior of vodka demand and vodka consumers, this paper first models a scenario in which the total milliliters of a specific type of vodka are explored to evaluate the impacts of changes in: the price of that vodka, the price of all other vodkas, the price of beer, the price of wine, the average price of all liquors other than vodka (summed and averaged into their own unique variable), per capita personal income, unemployment, population, and controlled on the basis county, month, and the year on the total milliliters sold. Next, the paper models a scenario based on the exact same variables and assumptions as our first model, with the notable amendment being that alcohols other than vodka are not summed to one variable, but instead the impact on the milliliters of a specific vodka are modeled on each alcohols individual price.

3.2 Literature Review

The focus of the research presented in this paper is centering around liquor markets and the ways in which they operate; more narrowly defined to just be on that of vodka; it is necessary to understand how alcohol economics as a whole have been addressed and analyzed in the existing literature. Therefore, the first type of literature that this paper will fit under is the broad category addressing consumer demand for alcohol. This type of analysis has been explored and estimated extensively across a wide spectrum of methodologies and frameworks and across many nations such as in Selvanathan (2017). A survey of the existing literature regarding beer, wine, and spirits demand is provided by Fogarty (2010); with this study building upon the literature base by adjusting for the precision of each elasticity estimate as elasticity estimates will be influenced by such factors as estimation technique, data frequency and time period under consideration. The findings being that demand for alcoholic beverages has become less inelastic since the mid-1950s and that the income elasticity has been falling since the mid-1960s. Further analysis provides support for the idea that alcohol as a commodity group is a necessity, and that consumers respond to price discounting with inventory behavior rather than true substitution behavior. Another meta-analysis of the demand for alcohol, particularly focusing on price, income, and advertising elasticity's is provided in Gallet (2007) which highlights the results gleamed from different estimation methods employed by the various existing studies. Notable conclusions that the survey provides are: beginning with price elasticity, short-run elasticity estimates are more inelastic than long-run and the demand for beer is more price inelastic than wine, spirits, and alcohol. Moving on to income elasticity, the results are that once again short-run elasticity's are more inelastic than in the long-run, it is also summarized that the income elasticity is larger for wine, spirits, and alcohol than it is for beer. Finally, the results of advertising elasticity's are found to tend to be positive across alcohol type, with the demand for spirits being the most responsive to advertising. The research presented here provides an overview of how liquor markets and particularly the demand for alcohol looks in a very broad sense. Understanding how alcohol has been evaluated and specifically the results found regarding elasticity's serves to inform the development of our model as we aim to more closely examine the intricate substitution and demand behavior in the vodka alcohol subcategory.

Further, analysis found in Clements and Johnson (1983) illustrate how the system-wide approach to consumer demand can be extended so that it can be applied narrowly to defined commodity groups, in their particular case, beer, wine and spirits. When the consumer's utility function is appropriately separable in alcoholic beverages and all other goods, it is possible to confine attention to the three types of alcohol. Many studies approach the demand for beer, which while not identical to the demand for liquor, seeing as both beer and liquor are alcohol, there may exist some crossover in the determinants of demand for both. Heien and Pompelli (1989) estimate a demand system that considers all beverages simultaneously while incorporating the effect of demographics. Blake and Nied (1997) use an Almost Ideal Demand System (Aids) model to estimate demand for beer in the United Kingdom. Toro-González et al. (2014) analyzes the demand for beer as a differentiated product and estimates own-price, cross-price, and income elasticity's for beer by type: craft beer, mass-produced beer, and imported beet. The results of their analysis finding that there are effectively separate markets for beer by type.

Additional research examines the factors that are expected to influence beverage consumption. Levy and Sheflin (1985) utilize a Cobb-Douglass consumption function in which per capita consumption of alcoholic beverages depends on real per capita disposable income and the relative price of alcoholic beverages to personal income. They find that total demand for alcoholic beverages is inelastic and discover weak evidence of a higher propensity to consume alcoholic beverages by those under the age of twenty-one. Baltagi and Griffin (1995) estimates a dynamic model for liquor in the United States using a panel data set of 43 states, modeling consumption on real price, per capita income, a vector of time varying tastes, export demand to neighboring states, and the potential for imports from neighboring states. The model ultimately finds that in the long-run the price is relatively inelastic, there exists small positive income elasticity, and very weak evidence of bootlegging across states.

Demand for alcoholic beverages is further evaluated in Nelson (1999) in which the effects of advertising are explored to determine how advertising affect alcohol consumption. Empirical results also are reported for total consumption of pure alcohol. The results for the three beverages and total alcohol indicate that advertising has little or no effect on demand. The results indicate that advertising has little or no effect on demand. The empirical evidence therefore supports the notion that regardless of media, advertising affects mainly brand shares. Ornstein and Hanssens (1985) tests the social marketing effectiveness of alcohol control laws designed to reduce the consumption of alcoholic beverages with the findings being that the main determinants of interstate differences in consumption of spirits are price, income, and interstate travel, not differences in alcohol control laws.

Beyond the demand and consumption studies, further literature appropriate for our analysis focuses on the substitution for alcohol. Gruenewald et al. (2006) explores how consumers make substitution decisions between purchases of different alcohol types and brands in response to changes in prices. The study assesses the relationship between alcohol beverages prices, beverage quality, and alcohol sales. The results presented show that consumers respond to price increase by altering their total consumption and by varying their brand choice and significant reductions in sales were observed in response to price increases, but these effects were mitigated by significant substitutions between quality classes. Further studies examining substitution in alcohol include Winfree and Watson (2015) and Watson et al. (2020) which analyses the economic effects of a change in liquor policy in 2012 in Washington state, with a portion of the analysis focusing on the cross-border spillover effects and the substitutability of liquor from vendors across stateliness in response to policy changes. The findings being that a change in liquor laws in one state that result in higher prices to consumers has a statistically significant and measurable effect on liquor sales in a bordering state. Further researching delving into substitution deals with policy designed to reduce alcohol consumption and how consumers substitute their consumption in response. Moore (2010) provides a review and discussion of the of policy interventions dealing with the substitution and complementarity of alcohol. With the focus of this review centering on substitution in the face of policy decisions, the results are that Policies aimed at reducing alcohol consumption can be successful. However, evidence suggests a significant minority of consumers are likely to substitute or complement consumption with a range of intoxicants suggesting that policy is unlikely to reduce all-cause mortality and morbidity. Williams et al. (2005) investigates the impact of campus bans on alcohol use and the price of alcohol on college students drinking intensity. The results being that the effectiveness of a ban depends on the student's ability to substitute off campus, when substitution is easier, the ban is less effective. Also found is that increasing the price of alcohol appears to be equally as effective as a ban. It is apparent that the existing literature is lacking in terms of any research delving into how an individual liquor group is substituted within and outside the group classification. As this will be a main focus of our analysis, we can broaden and improve the existing literature concerning how and where alcohol substitution occurs.

A final applicable literature focuses on the importance of a reliable and appropriate data set for use in liquor analysis. Ruhm et al. (2011) explores how estimates of price elasticity of demand for beer vary with the choice of alcohol price series examined, exploring how using the correct data set and methodology is increasingly significant as estimates conducted using different sources vary drastically and unpredictably. Young and Bielinska-Kwapisz (2003) also presents a similar stance while investigating alcohol consumption, beverages prices, and measurement error, finding that price data is substantially contaminated with measurement error when using a national data source such as ACCRA. Both of these studies highlight the importance of using not only a complete and profound data set but one that appropriately address the analysis you which to conduct when aiming to gleam meaningful and significant results.

3.3 Methodology

3.4 Data

The data for this study came from the Idaho State Liquor Division and represent all of the individual liquor store transactions that took place from July 2007 through 2020 aggregated monthly. The data is detailed to the individual bottle (brand, type, and size) and capture all liquor transactions at the store level of detail across the entire state, including both urban and rural areas. Minimum sales prices of liquor in Idaho are set by the Idaho State Liquor Division. Individual stores have the latitude to charge a higher price than the state minimum but not a lower price. In practice, only a very small fraction of stores ever charge a different price for a given bottle than the state minimum. The provided liquor data is then combined with data on per capita income, population, and consumer price index values for beer and wine that were obtained from the U.S. Bureau of Economic Analysis, data on unemployment was obtained from the U.S. Bureau of Labor Statistics, pertaining to each county and FIPS code in the state of Idaho, for any given year. These three sources comprise our master data-set. After constructing the master data-set, the data is broken down to represent the markets for the five classifications of vodka by the Idaho State Liquor Division, Flavored Imported, Flavored Domestic, Domestic, Domestic 100 Proof, and Imported Vodka, with each subset consisting of over 26,000 observations, we aggregated these transactions so that our unit of observation is quantity of liquor sold by type (i), store (j), month (k), and year (l).

3.5 Model

Two models were constructed for the purpose of analysis. In the first model all liquors other than vodka are summed and averaged into their own unique variable. The model is estimated as a reduced linear functional form as follows:

$$lnQ_{ijkl} = \alpha + \beta(lnP_{ikl}) + \gamma(lnS_{ikl}) + \delta(lnB_{kl}) + \epsilon(lnW_{kl}) + \phi(lnA_{kl}) + \theta(lnI_{kl}) + \lambda(lnX_{kl}) + \omega(lnU_{kl}) + \rho(C_{kl}) + \chi(M_k) + \tau(Y_l) + \upsilon(L_{kl}) + \mu$$

where Q is the quantity of type i vodka sold in liters in store j in month k and year l, P own price of liquor sold in month k and year l, S is the price of type vodka(s) sold in month k and year l, W is the price of wine sold in month k and year l, B is the price of beer sold ib month k and year l, A is the average price of all liquor other than vodka sold in month k and year l, I is real per capita personal income in the county where the store is located , X is the population in the county in where the store is located, U is the unemployment rate in the county where the store is located, C is an indicator variable equal to 1 if it is a month during the COVID-19 pandemic and a 0 otherwise, M is a month fixed effect, Y is the year fixed effect, L is the store fixed effect, and U represents a random error.

The next model does not sum and average all other liquors, instead leaving each liquor type as it's own individual variable. The model is estimated as a reduced linear functional form as follows:

$$lnQ_{ijkl} = \alpha + \beta(lnP_{ikl}) + \gamma(lnS_{ikl}) + \delta(lnB_{kl}) + \epsilon(lnW_{kl} + \phi(lnA_{ikl}) + \theta(lnI_{kl}) + \lambda(lnX_{kl}) + \omega(lnU_{kl}) + \rho(C_{kl}) + \chi(M_k) + \tau(Y_l) + \upsilon(L_{kl}) + \mu$$

With the notable amendment being that, A represents the price of type i alcohol sold in month k and year l. Both estimations use robust standard errors.

3.6 Results

Summary statistics for the variables used in our two models are presented in Table 2 respectively. The results of our first demand model for Flavored Imported Vodka (with the average alcohol variable) is presented in Table 3. The tables show us that, Flavored Domestic Vodka, Domestic Vodka, Beer, and our average price of all other liquors are substitutes with Flavored Domestic, beer, and all other liquors being statistically significant. Domestic 100 Proof and Imported Vodka being both being complements for Flavored Imported Vodka. Income was positive and significant, the effect of unemployment was negative and significant, the population effect was positive but not significant, months during the COVID-19 pandemic did not have a significant impact on the milliliters of Flavored Imported Vodka that were sold.

Table 4 paint a slightly different picture as we can see which exact liquors have a significant impact on the total milliliters of Flavored Imported Vodka sold. Flavored Domestic Vodka , Domestic Vodka , Beer, Wine, Rye Whiskey, Canadian Whiskey, Imported Gin, Moonshine, Triple Sec, and Wines (Port), are all statistically significant substitutes. The statistically significant compliments are: Domestic 100 Proof Vodka, Tennessee Whiskey, Blended Whiskey, Single Malt Scotch Whiskey, Brandy (Domestic), Brandy (Flavored Imported), Rum (Flavored)), Creme Liqueurs, Tequila (Silver), and Tequila (Gold). Income was positive and significant, unemployment was negative and significant, and months during the COVID-19 pandemic also had a positive and significant impact on the milliliters of Flavored Imported Vodka that were sold.

The results of our first demand model for Flavored Domestic Vodka (with the average alcohol variable) is presented in Table 5. The tables show us that, Imported Vodka, beer, and all other liquors being statistically significant substitutes for Flavored Domestic Vodka. There were no statistically significant compliments found in this model. Income was positive and significant, the effect of unemployment and the population was negative and significant. Months during the COVID-19 pandemic did have a positive significant impact on the milliliters of Flavored Domestic Vodka that were sold.

The results of our second demand model for Flavored Domestic Vodka is presented in Table 6. The findings being that: Canadian Whiskey, Blended Scotch Whiskey, Brandy (Imported), Cordials/Liqueurs, and Triple Sec were all statistically significant substitutes. Irish Whiskey, American Light Whiskey, Rum, Creme Liqueurs, Tequila (Gold), Tequila (Resposado), and Tequila (Anejo) were all statistically significant compliments. Income and months during the COVID-19 pandemic were positive and significant. Population and unemployment were negative and statistically significantly impacted the milliliters of Flavored Domestic Vodka that were sold.

The results of our first demand model for Domestic Vodka (with the average alcohol variable) is presented in Table 7. These tables show us that, Flavored Imported Vodka, Flavored Domestic Vodka, and wine are statistically significant substitutes for Domestic Vodka. The statistically significant compliments found in this model are: Domestic 100 Proof Vodka and Imported Vodka. Population and months during the COVID-19 pandemic did have a positive significant impact on the milliliters of Domestic Vodka that were sold while Unemployment had a negative significant impact.

The results of our second demand model for Domestic Vodka is presented in Table 8. The findings being that: Flavored Imported Vodka, Wine, Canadian Whiskey, and Triple Sec were all statistically significant substitutes. Domestic 100 Proof Vodka, Irish Whiskey, American Light Whiskey, Blended Whiskey, Brandy (Flavored), Tequila (Gold), Tequila (Resposado), and Tequila (Anejo) were all statistically significant compliments. Population and months during the COVID-19 pandemic were positive and significant. Unemployment was negative and statistically significantly impacted the milliliters of Flavored Domestic Vodka that were sold.

The results of our first demand model for Domestic 100 Proof Vodka (with the average alcohol variable) is presented in Table 9. These tables show us that, Flavored Imported Vodka and beer are statistically significant substitutes for Domestic 100 Proof Vodka. The statistically significant compliments found in this model are: Flavored Domestic Vodka, Domestic Vodka, and Imported Vodka. Income and Population did have a positive significant impact on the milliliters of Domestic Vodka that were sold while Unemployment had a negative significant impact.

The results of our second demand model for Domestic 100 Proof Vodka is presented in Table 10. The findings being that: Flavored Imported Vodka, Beer, Rye Whiskey, Brandy (Domestic), Brandy (Flavored Imported), Gin (Specialty), Moonshine, Cordials/Liqueurs, and Tequila (Silver) were all statistically significant substitutes. Domestic Vodka, Imported Vodka, Wine, Irish Whiskey, American Light Whiskey, Blended Whiskey, Blended Scotch Whiskey, Brandy (Cognac), Gin (Domestic), and Coffee Liqueurs were all statistically significant compliments. Income and months during the COVID-19 pandemic were positive and significant, while Unemployment was negative and statistically significantly impacted the milliliters of Flavored Domestic 100 Proof Vodka that were sold.

The results of our first demand model for Imported Vodka (with the average alcohol variable) is presented in Table 11. These tables show us that, Flavored Domestic Vodka, Domestic Vodka, Beer and Wine were statistically significant substitutes for Imported Vodka. The model found no statistically significant compliments. Income and unemployment had a negative significant impact on the milliliters of Domestic Vodka that were sold while Population and months during the COVID-19 Pandemic had a positive significant impact.

The results of our second demand model for Imported Vodka is presented in Table 12. The findings being that: Flavored Domestic Vodka, Beer, Wine, Blended Scotch Whiskey, Single Malt Scotch Whiskey, Brandy (Domestic), Brandy (Imported), Brandy (Cognac), and Brandy (Flavored Imported) were all statistically significant substitutes. Bourbon, Coffee Liqueurs, Tequila (Reposado), and Tequila (Anejo) were all statistically significant compliments. Income and Unemployment were negative and significant, while Population and months during the COVID-19 pandemic was positive and statistically significantly impacted the milliliters of Imported Vodka that were sold.

3.7 Conclusion

This paper presents the markets for the five distinct vodka types as defined by the State of Idaho Liquor Division, most notably highlighting the impact that changes in own price and the prices of other alcohols have on the consumption of a choice vodka; while also presenting how income, population, unemployment and COVID also influenced the consumption of each vodka classification. The key findings being that increases in the own price of the choice vodka significantly decrease the consumption, while changes in the price of other vodka and other alcohols (either summed and averages as one variables or left independently) may either increase or decrease consumption as each market as consumers make varying decisions in how they choose to consumer their vodka. The impacts of income, population growth, unemployment, and the COVID-19 pandemic also impacted each vodka classification differently once again adding credence that the markets exist independently from one another.

In the creation and analysis of the focus model, this research has shown that individual liquor types, in this case vodka, can be modeled and described as their own distinct market places, with varying income and substitution effects. A model that has never before been presented in the literature and providing a new method for analysing the demand for alcohol beyond the historical classifications of just beer, wine, and liquor.

While in itself innovative, the research here still presents gaps for future analysis to delve into. Further research to be examined exists in that of other alcohol types. While vodka was the focus of this paper, the markets for whiskey, rum, gin, etc all exist to be explored an examined. The impacts of marketing and advertising are also left out of the model(s) presented in this research and would may result in an outcome different from the findings presented here.

Table 2: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.
Log of Milliliter Sold: Vodka, Flavored Imported	10.079	1.725	5.521	13.848
Log Liters Sold: Vodka, Flavored Domestic	10.744	1.911	5.521	15.465
Log Milliliters Sold: Vodka, Domestic	12.988	1.534	1.534	16.732
Log Milliliters Sold: Vodka, Domestic 100 Proof	9.831	1.467	4.828	12.831
Log Milliliters Sold: Vodka, Imported	10.602	1.819	5.298	14.409
Log of own price: Vodka, Flavored Imported	3.229	0.195	1.831	4.012
Log of own price: Vodka, Flavored Domestic	3.083	0.215	2.210	3.785
Log of own price: Vodka, Domestic	2.507	0.165	2.076	3.533
Log of own price: Vodka, Domestic 100 Proof	2.921	0.188	2.404	4.145
Log of own price: Vodka, Imported	3.419	0.155	2.438	4.903
Log of unemployment rate	-2.978	0.517	-4.605	-1.452
Log of consumer price index for beer	5.349	0.068	5.191	5.483
Log of consumer price index for wine	5.130	0.014	5.079	5.158
Log of population by county by year	10.646	1.471	6.948	13.111
Log of per capita personal income	10.521	0.243	9.797	11.676
Log of own price: Rye Whiskey	3.433	0.272	2.943	3.772
Log of own price: Tennessee Whiskey	3.367	0.034	3.271	3.429
Log of own price: Bourbon	3.012	0.177	2.723	3.381
Log of own price: Irish Whiskey	3.615	0.063	3.447	3.721
Log of own price: American Light Whiskey	3.118	0.325	2.553	3.626
Log of own price: Blended Whiskey	2.668	0.381	2.293	3.133
Log of own price: Canadian Whiskey	2.707	0.090	2.570	2.928
Log of own price: Blended Scotch Whiskey	3.164	0.119	2.958	3.469
Log of own price: Single Malt Scotch Whiskey	4.184	0.095	4.019	4.426
Log of own price: Brandy, Domestic	2.665	0.058	2.534	2.755
Log of own price: Brandy, Imported	3.092	0.062	2.939	3.272
Log of own price: Brandy, Cognac	3.972	0.084	3.802	4.390
Log of own price: Brandy, Flavored	2.828	0.060	2.729	2.966
Log of own price: Brandy, Flavored Imported	3.459	0.050	3.313	3.582
Log of own price: Rum	2.603	0.044	2.499	2.722
Log of own price: Rum, Flavored	2.889	0.020	2.811	2.930
Log of own price: Gin, Domestic	2.430	0.102	2.288	2.668
Log of own price: Gin, Imported	3.323	0.039	3.238	3.409
Log of own price: Gin, Specialty	2.557	0.161	2.321	2.805
Log of own price: Cocktails/Bitters	2.701	0.203	2.417	3.262
Log of own price: Moonshine	3.222	0.174	2.465	3.525
Log of own price: Cordials/Liqueurs	3.184	0.084	3.075	3.338
Log of own price: Coffee Liqueurs	2.990	0.069	2.839	3.126
Log of own price: Amaretto	3.182	0.066	3.012	3.350
Log of own price: Crème Liqueurs	3.134	0.122	2.804	3.399
Log of own price: Triple Sec	2.313	0.064	2.191	2.434
Log of own price: Wines, Port	3.360	0.103	2.804	3.634
Log of own price: Tequila, Blanco/Silver	3.233	0.247	2.814	3.617
Log of own price: Tequila, Gold	2.971	0.040	2.898	3.063
Log of own price: Tequila, Repusado	3.456	0.069	3.353	3.670
Log of own price: Tequila, Anejo	4.143	0.088	3.974	4.322
Log of avg. price of non-Vodka liquor	3.340	0.153	3.107	3.618
Dummy months for COVID-19 pandemic	0.036	0.187	0	1

Table 3: Determinants of Demand for Vodka, Flavored Imported (average alcohol)

Variable of Interest	Parameter Estimate	Standard Error
Constant	-19.216**	5.564
Log of own price	-1.218**	0.051
Log of price of Vodka, Flavored Domestic	1.022**	0.188
Log of price of Vodka, Domestic	0.433	0.292
Log of price of Vodka, Domestic 100 Proof	-1.007**	0.198
Log of price of Vodka, Imported	-0.586**	0.159
Log of consumer price index for beer	6.706**	0.916
Log of consumer price index for wine	-1.124	0.668
Log of average price of all other liquors	0.301**	0.110
Log of unemployment	-0.148**	0.022
Log of per capita personal income	0.613**	0.103
Log of population	-0.036	0.118
Log of dummy for months during COVID-19	0.087	0.045
R^2	.9005	
N	26,426	

Table 4: Determinants of Demand for Vodka, Flavored Imported (all alcohol)

Variable of Interest	Parameter Estimate	Standard Error
Constant	-32.893***	(7.697)
Log of own price	-1.197**	(0.051)
Log of price of Vodka, Flavored Domestic	0.864**	(0.273)
Log of price of Vodka, Domestic	1.534**	(0.452)
Log of price of Vodka, Domestic 100 Proof	-0.974**	(0.272)
Log of price of Vodka, Imported	-0.159	(0.210)
Log of consumer price index for beer	7.434**	(1.156)
Log of consumer price index for wine	2.307*	(0.896)
Log of price of Rye Whiskey	0.233*	(0.118)
Log of price of Tennessee Whiskey	-0.775*	(0.326)
Log of price of Bourbon	-0.243	(0.402)
Log of price of Irish Whiskey	-0.091	(0.214)
Log of price of American Light Whiskey	-0.143	(0.087)
Log of price of Blended Whiskey	-0.377**	(0.122)
Log of price of Canadian Whiskey	3.306**	(0.563)
Log of price of Blended Scotch Whiskey	-0.726	(0.468)
Log of price of Single Malt Scotch Whiskey	-0.590**	(0.187)
Log of price of Brandy, Domestic	-2.078**	(0.443)
Log of price of Brandy, Imported	0.253	(0.143)
Log of price of Brandy, Cognac	-0.112	(0.088)
Log of price of Brandy, Flavored	0.406	(0.331)
Log of price of Brandy, Flavored Imported	-0.780**	(0.216)
Log of price of Rum	-0.203	(0.378)
Log of price of Rum, Flavored	-1.476**	(0.430)
Log of price of Gin, Domestic	-0.072	(0.440)
Log of price of Gin, Imported	0.956**	(0.304)
Log price of Gin, Specialty	-0.263	(0.151)
Log of price of Cocktails/Bitters	-0.177	(0.120)
Log of price of Moonshine	0.144**	(0.054)
Log of price of Cordials/Liqueurs	-0.002	(0.484)
Log of price of Coffee Liqueurs	0.075	(0.181)
Log of price of Amaretto	-0.126	(0.234)
Log price of Crème Liqueurs	-0.262*	(0.121)
Log of price of Triple Sec	1.703**	(0.243)
Log of price of Wines, Port	0.114*	(0.057)
Log of price of Tequila, Blanco/Silver	-0.532**	(0.148)
Log of price of Tequila, Gold	-0.727*	(0.334)
Log of price of Tequila, Reposado	0.357	(0.257)
Log of price of Tequila, Anejo	-0.271	(0.154)
Log of unemployment	-0.158**	(0.023)
Log of per capita personal income	0.613**	(0.104)
Log of population	-0.068	(0.118)
Log of dummy for months during COVID-19	0.169**	(0.063)
R^2	.9005	
N	26,426	

Table 5: Determinants of Demand for Vodka, Flavored Domestic (average alcohol)

Variable of Interest	Parameter Estimate	Standard Error
Constant	-8.682	0.043
Log of own price	-0.129**	0.031
Log of price of Vodka, Flavored Imported	0.026	0.159
Log of price of Vodka, Domestic	0.281	0.276
Log of price of Vodka, Domestic 100 Proof	-0.032	0.191
Log of price of Vodka, Imported	0.429**	0.153
Log of consumer price index for beer	2.439**	0.866
Log of consumer price index for wine	0.637	0.652
Log of average price of all other liquors	0.245*	0.101
Log of unemployment	-0.246**	0.021
Log of per capita personal income	0.557**	0.097
Log of population	-0.295**	0.105
Log of dummy for months during COVID-19	0.160**	0.043
R^2	.9266	
N	26,525	

Table 6: Determinants of Demand for Vodka, Flavored Domestic (all alcohol)

Variable of Interest	Parameter Estimate	Standard Error
Constant	3.662	7.087
Log of own price	-1.378**	0.037
Log of price of Vodka, Flavored Imported	0.159	0.197
Log of price of Vodka, Domestic	-0.581	0.437
Log of price of Vodka, Domestic 100 Proof	-0.009	0.263
Log of price of Vodka, Imported	0.310	0.208
Log of consumer price index for beer	0.932	1.038
Log of consumer price index for wine	-0.269	0.849
Log of price of Rye Whiskey	0.044	0.109
Log of price of Tennessee Whiskey	0.077	0.230
Log of price of Bourbon	-0.018	0.385
Log of price of Irish Whiskey	-0.679**	0.205
Log of price of American Light Whiskey	-0.248**	0.079
Log of price of Blended Whiskey	-0.031	0.112
Log of price of Canadian Whiskey	1.632**	0.515
Log of price of Blended Scotch Whiskey	1.880**	0.445
Log of price of Single Malt Scotch Whiskey	0.242	0.179
Log of price of Brandy, Domestic	0.730	0.414
Log of price of Brandy, Imported	0.286*	0.135
Log of price of Brandy, Cognac	-0.098	0.081
Log of price of Brandy, Flavored	-0.155	0.314
Log of price of Brandy, Flavored Imported	0.136	0.197
Log of price of Rum	-1.890**	0.349
Log of price of Rum, Flavored	-0.444	0.396
Log of price of Gin, Domestic	0.566	0.406
Log of price of Gin, Imported	0.353	0.282
Log price of Gin, Specialty	-0.137	0.140
Log of price of Cocktails/Bitters	-0.208	0.123
Log of price of Moonshine	-0.028	0.049
Log of price of Cordials/Liqueurs	1.611**	0.458
Log of price of Coffee Liqueurs	-0.155	0.165
Log of price of Amaretto	-0.202	0.224
Log price of Crème Liqueurs	-0.247*	0.114
Log of price of Triple Sec	0.649**	0.227
Log of price of Wines, Port	0.007	0.055
Log of price of Tequila, Blanco/Silver	0.116	0.140
Log of price of Tequila, Gold	-0.747*	0.311
Log of price of Tequila, Reposado	-0.880**	0.243
Log of price of Tequila, Anejo	-0.316*	0.139
Log of unemployment	-0.311**	0.022
Log of per capita personal income	0.515**	0.097
Log of population	-0.367**	0.105
Log of dummy for months during COVID-19	0.226**	0.056
R^2	.9266	
N	26,525	

Table 7: Determinants of Demand for Vodka, Domestic (average alcohol)

Variable of Interest	Parameter Estimate	Standard Error
Constant	-9.181**	3.089
Log of own price	-0.974**	0.061
Log of price of Vodka, Flavored Imported	0.282**	0.096
Log of price of Vodka, Flavored Domestic	0.365**	0.104
Log of price of Vodka, Domestic 100 Proof	-0.393**	0.111
Log of price of Vodka, Imported	-0.189*	0.095
Log of consumer price index for beer	1.010	0.517
Log of consumer price index for wine	1.034**	0.373
Log of average price of all other liquors	-0.009	0.059
Log of unemployment	-0.192**	0.012
Log of per capita personal income	0.048	0.043
Log of population	1.122**	0.064
Log of dummy for months during COVID-19	0.169**	0.027
R^2	.9608	
N	26,459	

Table 8: Determinants of Demand for Vodka, Domestic (all alcohol

Variable of Interest	Parameter Estimate	Standard Error
Constant	0.014	4.048
Log of own price	-0.975**	0.061
Log of price of Vodka, Flavored Imported	0.394**	0.117
Log of price of Vodka, Flavored Domestic	0.278	0.152
Log of price of Vodka, Domestic 100 Proof	-0.339*	0.155
Log of price of Vodka, Imported	-0.064	0.127
Log of consumer price index for beer	-0.136	0.620
Log of consumer price index for wine	1.185*	0.476
Log of price of Rye Whiskey	-0.026	0.062
Log of price of Tennessee Whiskey	-0.100	0.177
Log of price of Bourbon	-0.234	0.220
Log of price of Irish Whiskey	-0.447**	0.118
Log of price of American Light Whiskey	-0.123**	0.047
Log of price of Blended Whiskey	-0.149*	0.064
Log of price of Canadian Whiskey	0.627*	0.300
Log of price of Blended Scotch Whiskey	0.340	0.257
Log of price of Single Malt Scotch Whiskey	-0.016	0.104
Log of price of Brandy, Domestic	0.388	0.238
Log of price of Brandy, Imported	0.068	0.076
Log of price of Brandy, Cognac	-0.006	0.047
Log of price of Brandy, Flavored	-0.361*	0.178
Log of price of Brandy, Flavored Imported	-0.021	0.118
Log of price of Rum	-0.293	0.220
Log of price of Rum, Flavored	-0.280	0.235
Log of price of Gin, Domestic	0.135	0.241
Log of price of Gin, Imported	0.195	0.164
Log price of Gin, Specialty	-0.034	0.085
Log of price of Cocktails/Bitters	-0.042	0.073
Log of price of Moonshine	0.017	0.028
Log of price of Cordials/Liqueurs	0.139	0.271
Log of price of Coffee Liqueurs	-0.105	0.101
Log of price of Amaretto	0.053	0.132
Log price of Crème Liqueurs	-0.024	0.066
Log of price of Triple Sec	0.340**	0.131
Log of price of Wines, Port	0.019	0.031
Log of price of Tequila, Blanco/Silver	-0.069	0.080
Log of price of Tequila, Gold	-0.414*	0.185
Log of price of Tequila, Reposado	-0.473**	0.147
Log of price of Tequila, Anejo	-0.176*	0.084
Log of unemployment	-0.218**	0.013
Log of per capita personal income	0.034	0.043
Log of population	1.098**	0.064
Log of dummy for months during COVID-19	0.225**	0.037
R^2	.9608	
N	26,459	

Table 9: Determinants of Demand for Vodka, Domestic 100 Proof (average alcohol)

Variable of Interest	Parameter Estimate	Standard Error
Constant	-15.414**	5.322
Log of own price	-1.351**	0.043
Log of price of Vodka, Flavored Imported	0.664**	0.163
Log of price of Vodka, Flavored Domestic	-0.221	0.176
Log of price of Vodka, Domestic	-1.054**	0.285
Log of price of Vodka, Imported	-0.925**	0.161
Log of consumer price index for beer	4.739**	0.852
Log of consumer price index for wine	-0.147	0.622
Log of average price of all other liquors	-0.182	0.108
Log of unemployment	-0.163**	0.021
Log of per capita personal income	0.496**	0.107
Log of population	0.303*	0.119
Log of dummy for months during COVID-19	0.077	0.045
R^2	.8818	
N	26,592	

Table 10: Determinants of Demand for Vodka, Domestic 100 Proof (all alcohol)

Variable of Interest	Parameter Estimate	Standard Error
Constant	3.034	7.197
Log of own price	-1.332**	0.043
Log of price of Vodka, Flavored Imported	0.588**	0.201
Log of price of Vodka, Flavored Domestic	-0.149	0.260
Log of price of Vodka, Domestic	-1.211**	0.466
Log of price of Vodka, Imported	-0.763**	0.211
Log of consumer price index for beer	2.174*	1.051
Log of consumer price index for wine	-2.091*	0.848
Log of price of Rye Whiskey	0.477**	0.115
Log of price of Tennessee Whiskey	0.581	0.305
Log of price of Bourbon	-0.500	0.386
Log of price of Irish Whiskey	-0.921**	0.208
Log of price of American Light Whiskey	-0.619**	0.084
Log of price of Blended Whiskey	-0.263*	0.118
Log of price of Canadian Whiskey	-0.024	0.518
Log of price of Blended Scotch Whiskey	-1.758**	0.452
Log of price of Single Malt Scotch Whiskey	-0.227	0.189
Log of price of Brandy, Domestic	2.466**	0.436
Log of price of Brandy, Imported	-0.124	0.146
Log of price of Brandy, Cognac	-0.157*	0.073
Log of price of Brandy, Flavored	-0.387	0.307
Log of price of Brandy, Flavored Imported	0.813**	0.194
Log of price of Rum	0.485	0.367
Log of price of Rum, Flavored	0.276	0.399
Log of price of Gin, Domestic	-1.167**	0.428
Log of price of Gin, Imported	0.225	0.281
Log price of Gin, Specialty	0.821**	0.154
Log of price of Cocktails/Bitters	0.138	0.116
Log of price of Moonshine	0.133**	0.048
Log of price of Cordials/Liqueurs	1.885**	0.482
Log of price of Coffee Liqueurs	-0.889**	0.171
Log of price of Amaretto	0.363	0.234
Log price of Crème Liqueurs	-0.103	0.106
Log of price of Triple Sec	0.021	0.227
Log of price of Wines, Port	-0.064	0.056
Log of price of Tequila, Blanco/Silver	0.444**	0.149
Log of price of Tequila, Gold	0.286	0.310
Log of price of Tequila, Reposado	-0.367	0.245
Log of price of Tequila, Anejo	0.116	0.150
Log of unemployment	-0.228**	0.023
Log of per capita personal income	0.404**	0.108
Log of population	0.260	0.119
Log of dummy for months during COVID-19	0.235**	0.064
R^2	.8818	
N	26,592	

Table 11: Determinants of Demand for Vodka, Imported (average alcohol)

Variable of Interest	Parameter Estimate	Standard Error
Constant	-20.159**	4.880
Log of own price	-0.895**	0.045
Log of price of Vodka, Flavored Imported	-0.214	0.137
Log of price of Vodka, Flavored Domestic	0.371*	0.154
Log of price of Vodka, Domestic	1.053**	0.251
Log of price of Vodka, Domestic 100 Proof	-0.197	0.174
Log of consumer price index for beer	3.126**	0.815
Log of consumer price index for wine	2.722**	0.577
Log of average price of all other liquors	0.100	0.093
Log of unemployment	-0.243**	0.018
Log of per capita personal income	-0.584**	0.073
Log of population	0.696**	0.098
Log of dummy for months during COVID-19	0.111**	0.042
R^2	.9309	
N	26,494	

Table 12: Determinants of Demand for Vodka, Imported (all alcohol)

Variable of Interest	Parameter Estimate	Standard Error
Constant	-12.156	6.793
Log of own price	-0.899**	0.045
Log of price of Vodka, Flavored Imported	-0.340	0.175
Log of price of Vodka, Flavored Domestic	0.591*	0.241
Log of price of Vodka, Domestic	0.669	0.408
Log of price of Vodka, Domestic 100 Proof	0.127	0.245
Log of consumer price index for beer	2.405*	1.028
Log of consumer price index for wine	2.035**	0.779
Log of price of Rye Whiskey	0.019	0.100
Log of price of Tennessee Whiskey	0.471	0.277
Log of price of Bourbon	-1.339**	0.341
Log of price of Irish Whiskey	0.046	0.191
Log of price of American Light Whiskey	-0.090	0.073
Log of price of Blended Whiskey	0.068	0.105
Log of price of Canadian Whiskey	0.481	0.472
Log of price of Blended Scotch Whiskey	1.678**	0.403
Log of price of Single Malt Scotch Whiskey	0.361*	0.165
Log of price of Brandy, Domestic	1.512**	0.386
Log of price of Brandy, Imported	0.294*	0.126
Log of price of Brandy, Cognac	0.173*	0.077
Log of price of Brandy, Flavored	-0.361	0.286
Log of price of Brandy, Flavored Imported	0.389*	0.178
Log of price of Rum	-0.402	0.335
Log of price of Rum, Flavored	0.162	0.367
Log of price of Gin, Domestic	-0.470	0.386
Log of price of Gin, Imported	-0.400	0.263
Log price of Gin, Specialty	-0.220	0.137
Log of price of Cocktails/Bitters	0.028	0.106
Log of price of Moonshine	0.083	0.044
Log of price of Cordials/Liqueurs	-0.464	0.429
Log of price of Coffee Liqueurs	-0.663**	0.164
Log of price of Amaretto	-0.189	0.209
Log price of Crème Liqueurs	0.047	0.101
Log of price of Triple Sec	-0.203	0.209
Log of price of Wines, Port	-0.054	0.051
Log of price of Tequila, Blanco/Silver	0.168	0.130
Log of price of Tequila, Gold	-0.170	0.293
Log of price of Tequila, Reposado	-0.476*	0.229
Log of price of Tequila, Anejo	-0.504**	0.129
Log of unemployment	-0.286**	0.020
Log of per capita personal income	-0.605**	0.074
Log of population	0.660	0.098
Log of dummy for months during COVID-19	0.172**	0.054
R^2	.9309	
N	26,494	

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