Industry dynamics and the value of variety in nightlife: evidence from Chicago*

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Job Market Paper

Abstract

Access to high-quality local services constitutes an important amenity in residents' valuation of cities. This study examines consumer preferences for variety in nightlife to understand these preferences and their impact on nightlife industry dynamics. I develop a continuous-time structural dynamic model that parameterizes consumer preferences and describes venue entry and exit in the nightlife industry. In this model, consumers prefer access to variety in nearby venues and consume nightlife more often when the potential consumption utility increases. I estimate the model using a panel of liquor license data from Chicago. I find strong preferences for variety, both between and within different types of venues. The preference for variety (and the attendant increase in demand as variety increases) is sufficiently strong that on the median the increase in demand largely offsets the impact of additional competition on profit for incumbent venues. In particular, a new entrant without music, dance, or other amusement amenities raises consumer welfare as much as a 13.5% price reduction and lowers profits for other venues of the same type by less than 3%. However, potential entrants face high barriers to entry equivalent to six or seven years' revenue.

1 Introduction

Consumer access to city-specific non-tradeable goods and services play an integral role in the growth and development of cities. Glaeser, Kolko and Saiz (2001) suggest that the welfare gain from these consumption amenities in cities is an increasingly important factor in overall

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urban growth and an active literature has indicated the importance of consumption amenities to urban migration decisions (Rappaport, 2008; Lee, 2010; Albouy et al., 2013). The value of amenities to urban quality of life is also recognized outside of the urban economics literature. For example, Bloomberg Businessweek includes restaurants, bars, libraries, museums, professional sports teams, and park space in its annual ranking of "America's 50 Best Cities" and Livability.com explicitly includes entertainment and cultural amenities in its "Top 100 Places to Live" rankings.

In this study, I focus on bars, clubs, pool halls, arcades, bowling alleys, and other private businesses which exist primarily to facilitate social interactions in an informal setting. (Throughout, I use the terms "nightlife venues" and "nightlife industry" to describe these businesses.) I estimate a structural model of the nightlife industry with panel data on venue entry and exit to investigate consumer preference for access to variety in nightlife venues. The structural model allows me to assess the impact of consumers' preference for variety on venue profit as well as venue entry and exit.

Nightlife has been recognized in the sociology literature (Farrer, 2008; Chew, 2009; Grazian, 2009) and in the urban policy literature (Heath, 1997; Campo and Ryan, 2008; Darchen, 2013*a*) as a particularly important amenity in shaping residents' views of cities. Peters and Lakomski (2010) directly connect vibrant nightlife to attracting "a creative class of talented professionals" and Dewan (2005) describes a "hipness battle" between US cities, including an effort in Lansing, Michigan under the "Cool Cities Initiative" to make the city more attractive to young professionals by providing shuttle buses between bars[1]. Many cities have enacted policies to encourage the development of nightlife, including several large centres in Britain (Heath, 1997), smaller cities in Indiana (Faulk, 2006), and rapidly growing cities such Guangzhou in China (Zeng, 2009).

Vibrant nightlife is closely associated with access to a variety of nightlife venues. Currid (2007) notes that a dense concentration of nightlife venues is more appealing to consumers than spatially isolated venues. As one lounge manager stated of a dense nightlife district in Philadelphia, "It gives you variety. You don't want to go to the same place" (Harris, 2003). Picone, Ridley and Zandbergen (2009) attribute this to a consumer preference for "bar-hopping" (that is, a preference for visiting many venues in one night). However, some consumers may instead prefer access to different venues on each night; in the context of

[1]As Zimmerman (2008) notes, policy makers often provide a rationale for encouraging nightlife in terms of the "creative class" concept advanced in Florida (2002) and Florida (2005), which asserts that a city will benefit from the influx of highly educated professionals if those professionals find the city a pleasant and enjoyable place to live.

nightclub design, Kaiser, Ekblad and Broling (2007) discuss the difficulty of simultaneously addressing the preferences of bar-hopping patrons and patrons who spend the entire night at a single venue. In both cases, understanding consumer preferences for variety in nightlife is essential to understanding the development and valuation of nightlife amenities.

An emerging economic literature studies consumer valuation of consumption amenities and particularly consumer preference for access to variety. These papers generally follow the framework for consumer preference for variety established by Feenstra (1994). Among others, Broda and Weinstein (2006) infer consumer preferences for variety in goods from trade data, Li (2012) and Handbury and Weinstein (2011) study gains from variety using evidence from grocery purchases, and Broda and Weinstein (2010) use barcode data to study turnover in product variety. The study most closely related to the present work is Couture (2014), which estimates consumer gains from access to variety of restaurants.

This study contributes to the literature by quantifying consumer preferences for variety in nightlife and modelling how these preferences impact nightlife industry dynamics and the level of nightlife services provided. I construct and estimate a dynamic structural model of nightlife venue entry and exit using license data from Chicago. The model accounts for the "vibrancy" of nightlife districts. That is, in situations where consumers attain higher utility by choosing to go out, more consumers choose to go out and profit can potentially be higher — not only for a new entrant, but also for incumbent venues. As the model predicts entry and exit rates as a function of structural parameters, I can estimate the structural parameters using only data on entry and exit; this strategy is necessary in the present context, where more-detailed information is generally unavailable.

Structural estimation allows for the measurement of consumer preferences for variety as well as the evaluation of counterfactual scenarios which take into account the dynamic responses of venues to each others' entry and exit decisions. The estimation strategy allows for direct control of local demographic and regulatory conditions, which assists in distinguishing venue aggregation from zoning restrictions and other local conditions[2].

This study also contributes to the broader urban economics literature which attempts to explain the observed colocation of economic activity and similar firms in particular. As discussed by Rosenthal and Strange (2004), Puga (2010), and many others, positive agglomeration effects for firms play a significant role in explaining the structure and concentration of economic activity in cities. More specifically, several theoretical studies including discuss

[2] As Datta and Sudhir (2013) note, accounting for local regulation is essential for accurate measurements of the benefits of firm colocation.

aspects of consumers' preferences and decision process which could rationalize colocation in industries which offer widely differentiated products. Wolinsky (1983) studies the role of consumers' imperfect information, while Fischer and Harrington (1996) and Konishi (2005) raise the related possibility of taste uncertainty. In these studies, the consumers' behaviour can lead to higher profit for colocating firms than for spatially distant firms.

The structural model I develop and estimate in this study attempts to explain observed patterns of venue location through the benefit consumers receive from access to many nearby venues. This complements previous reduced-form studies of observed firm colocation including Picone, Ridley and Zandbergen (2009), Freedman and Kosová (2012), and Krider and Putler (2013) and structural studies including Davis (2006), Jia (2008), and Dunne et al. (2013).

Data availability on the operations of nightlife venues is generally limited[3]. Accordingly, this study builds upon a literature in industrial organization which uses entry and exit information to estimate the profit function, including Bresnahan and Reiss (1991), Pesendorfer and Schmidt-Dengler (2003), Aguirregabiria and Mira (2007), Ryan (2012), Collard-Wexler (2013) and Dunne et al. (2013). This appears to be one of the first studies to adopt the continuous-time dynamic discrete choice framework proposed by Arcidiacono et al. (2012)[4]. This framework allows for the computationally-tractable estimation of a full-featured structural model with a large state space.

The results of the estimation suggest that consumers have very strong preferences for access to variety in nightlife venues. Consumers gain substantial utility from access to nearby venues of different types. In particular, their preference for access to variety is highest among venues without music, dancing, or other amenities (i.e. bars) and somewhat lower for nightclubs, performance venues, and other venue types. Overall, these preferences for variety are somewhat stronger than the consumer preferences for variety in restaurants discussed in Couture (2014) and comparable to the most variety-specific goods in Broda and Weinstein

[3]Sales data is available in some cases. Abbring and Campbell (2005) use monthly liquor sales history from a sample of Texas bars to study the survival of new firms. However, this sales data is not linked with other attributes of the venue such as the type of services it provides and therefore it is less helpful for the present study. Note that self-reported consumer expenditure on nightlife is prone to under-reporting and therefore unreliable; Bee, Meyer and Sullivan (2012) describe alcohol spending in the Consumer Expenditure Survey's diary survey as "especially badly reported" compared to other expenditure categories.

[4]In addition to the methodology, several other studies including Pesendorfer and Schmidt-Dengler (2003), Bajari, Benkard and Levin (2007), and Aguirregabiria and Mira (2007) and Pakes, Ostrovsky and Berry (2007) have described estimation strategies for inferring the structural profit function from a small set of observed actions. However, as discussed in further detail below, I adapt the framework suggested in Arcidiacono et al. (2012) because the continuous-time framework allows for full use of available data in a rich state space while preserving computational tractability.

(2006) and Broda and Weinstein (2010). These results are robust to substantial changes in specification. In the median neighbourhood, one new venue without music, dancing, or other amenities raises consumer welfare for nightlife consumers to a level equivalent to a 13.5% increase in nightlife expenditure.

Moreover, I find that consumer preference for variety is strong enough that in many observations a new entrant would *increase* the profit for incumbent competitors. That is, the estimated parameter values predict sufficiently strong preference for variety that the additional demand from a new venue largely compensates the effect additional competition on profit in many cases. This effect holds for incumbents of the same type as the entrant as well as for incumbents of different types.

Potential entrants face high barriers to entry. The average sunk cost of entry is on the order of $800,000, which is equivalent to six or seven years' revenue. This reduces consumers' welfare in terms of access to nightlife variety. These high barriers can partially be attributed to very local license restrictions (which vary widely across the city) although other barriers (including city-wide regulatory cost as well as non-regulatory costs) are much more significant. As discussed below, these values correspond closely with estimates in the industry literature.

The remainder of the paper is organized as follows. First, I outline a structural model for venue profits and venues' entry and exit decisions in a framework that lends itself to maximum likelihood estimation and counterfactual evaluation. Then, I estimate this model using business license data from Chicago. Finally, I discuss the results of this estimation in the context of consumer preferences for variety and conduct counterfactual exercises to investigate the role of these preferences in determining nightlife industry dynamics.

2 Model

To parametrize consumer preferences over nightlife amenities and the relationship between consumer preferences and venue entry and exit decisions, I describe a structural model for the nightlife industry. I build this model in stages. First, I outline a static model for venue profit and derive theoretical results that show venue profits may *increase* with the number of nearby venues due to consumer preferences for more variety in nightlife. Then, I embed this model of venue profit in a dynamic model that describes nightlife venue entry and exit. This dynamic model lends itself to the estimation strategy described by Arcidiacono et al. (2012).

Before proceeding, it will be helpful to explicitly discuss the modelling choices for consumers' preferences and venues' decision-making processes. I provide details on parametrization and estimation in further detail below.

I model consumer preferences using a constant substitution of elasticity (CES) utility function. This provides a tractable parameterization of consumer preferences in terms of variety. As well, the CES functional form makes the results broadly comparable with other estimates of consumer gains from access to variety, including Broda and Weinstein (2006), Broda and Weinstein (2010), and Couture (2014). However, as this model allows for the possibility that consumers do not go out and consumer nightlife, it is not entirely identical to those other models. This adjustment seems reasonable in the context of nightlife, where consumers frequently choose not to consume based on the quality of the outside options. In comparison, it seems highly unlikely that consumers would choose not to consume, for example, groceries regardless of any outside options.

As is common in the literature, this model abstracts from the individual-level microfoundations of this preference for variety. However, several explanations are possible and mutually compatible. If venues have idiosyncratically high-quality and low-quality nights, then risk-averse customers may gain higher utility from going out in a neighbourhood with many venues as this would minimize their search costs in finding a high-quality venue. This is compatible with both the imperfect-information model developed by Wolinsky (1983) and the taste-uncertainty model investigated by Fischer and Harrington (1996) and developed by Konishi (2005). Nightlife patrons seeking to meet new people may prefer situations with many nearby venues to maximize their prospects. All of these scenarios would lead to the empirically-observed preference for neighbourhoods with many venues[5].

I model venues' entry and exit decisions in a continuous-time environment. In this environment, potential entrants decide whether to enter the market and incumbent venues decide whether to exit. Agents are not able to update these decisions continuously. Instead, they receive opportunities via a Poisson process (which delivers opportunities at a constant rate). At each opportunity, a potential entrant may decide whether to enter and a potential incumbent may decide whether to exit. Transitions to the policy and demographic environment are governed by a Poisson process as well. While it requires some additional notation, the dynamic approach offers several advantages over standard discrete-time approaches:

- Allowing for continuous time (as opposed to aggregating daily liquor license obser-

[5] As shown by Anderson, De Palma and Thisse (1992) and noted in Couture (2014), the CES utility model yields equivalent choices to a model with logit shocks to consumer choices.

vations to a larger time scale) allows for use of the full information present in the data.

- In continuous time, simultaneous moves by two agents represents a measure-zero event. Accordingly, agents decisions' need not be integrated over all possible moves by other agents (and all possible exogenous transitions to the environment). This drastically reduces the computational burden required to estimate the model and allows for tractable estimation of a richer model.

- Discrete time periods imply that all agents all have their sole opportunity to make decisions at the same time, once per period. For example, discrete monthly periods would imply that venues decide whether to exit and enter the market simultaneously at the beginning of every month. Stochastic decision times likely represent a closer approximation to reality and relax the assumption that all decisions occur simultaneously.

2.1 Static model

The environment for the static model of the nightlife industry consists of venues and consumers. Specifically, the environment includes n_ℓ venues[6] of each type $\ell \in 1, 2, \ldots, L$. Each type of venue provides a different kind of nightlife service to consumers — for example, bars are one type while nightclubs are another. These venues serve a market represented by a continuum of consumers of measure $\bar{N}$. Each consumer has a budget w for nightlife services. Venues of a given type are symmetric — i.e., they face the same profit maximization problem. Consumers' utility includes preference for variety within and across venue types. The consumer decides whether to go out and consume nightlife services based on the realization of a reservation utility shock. Venues set their prices to maximize profit optimally in response to each others' prices and consumer preferences.

2.1.1 Consumer preferences

Consumer preferences in the model consist of a nested CES utility for consumption across nightlife venues with a reservation shock. The inner nest accounts for preferences between venues of the same type while the outer nest accounts for preference for variety across different types of venue. The reservation shock represents the possibility that consumers

[6]The static model presented here takes the number of venues as fixed. In the dynamic model outlined below, the number of venues changes with endogenous entry and exit decisions.

choose not to go out and consume any nightlife services. Because of the reservation shock, the number of patrons for nightlife services varies with the number and types of venues[7].

As mentioned previously, I use a constant elasticity of substitution (CES) framework to describe consumer preferences. Specifically, I assume that consumer utility has the following functional form:

$$U(q) = \max \left\{ \left(\sum_{\ell} \left(\sum_{i} q_{\ell i}^{\frac{\rho_\ell - 1}{\rho_\ell}} \right)^{\frac{\rho_\ell}{\rho_\ell - 1} \frac{\eta - 1}{\eta}} \right)^{\frac{\eta}{\eta - 1}} , V^* \right\} \tag{1}$$

The first case on the right-hand side of Equation 1 represents a situation where the consumer chooses to go out and consume nightlife services, while the second case represents a situation where the consumer chooses the reservation utility of not going out. The parameter ρ_ℓ is the constant elasticity of substitution between venues of type ℓ while the parameter η is the constant elasticity of substitution across venues of different types. By assumption, $\rho_\ell > \eta > 2$ for all types ℓ — that is, consumers are more willing to substitute between venues of the same type than across different types[8].

In the case where the consumer chooses to go out, the consumer chooses the level of consumption $q_{\ell i}^D$ for venue i of type ℓ subject to the budget constraint $\sum_i \sum_\ell p_{\ell i} q_{\ell i} \leq w$. For notational convenience, introduce the usual CES price indices $P_\ell = \left(\sum_i p_{\ell i}^{1-\rho_\ell} \right)^{\frac{1}{1-\rho_\ell}}$ and $P = \left(\sum_\ell P_\ell^{1-\eta} \right)^{\frac{1}{1-\eta}}$ Then, solving the consumer's problem for a given vector of prices $p = \{p_{11}, p_{11}, \ldots, p_{1n_1}, \ldots, p_{\ell i}, \ldots, p_{L1}, p_{L2}, \ldots, p_{Ln_L}\}$ gives the following demand for nightlife services from venue i of type ℓ:

$$q_{\ell i}^D = p_{\ell i}^{-1} \left(\frac{p_{\ell i}}{P_\ell} \right)^{-\rho} \left(\frac{P_\ell}{P} \right)^{-\eta} w \tag{2}$$

Substituting this demand into Equation 1 yields the following expression for the indirect

[7] This study focuses on consumers' preference for access to variety between venues. However, nightlife venues have an additional effect on preferences. Dense concentrations of bars and clubs are also associated with negative spatial externalities, including noise, crime, and litter (Campo and Ryan, 2008; Currid, 2007; Danner, 2003). Accordingly, nearby residents and other businesses demand regulation to reduce the number of venues (Campo and Ryan, 2008; Darchen, 2013*a*; Currid, 2007). The welfare calculations presented in this paper do not consider these negative externalities.

[8] The assumption $\eta > 2$ is particular to the present model with the added reservation shock. It is required to ensure a consistent and unique solution as shown in Proposition 1. In the more general model without the reservation utility shock, $\eta > 1$ is sufficient.

utility $V(p)$:

$$V(p) = wP^{\eta-1} \sum_{\ell} P_{\ell}^{-\eta} \tag{3}$$

The reservation shock V^* in Equation 1 is a uniformly distributed random variable on $[0, 1]$. (Setting the maximum value of the shock to unity normalizes the prices in the model.) Each of the $\bar{N}$ measure-zero consumers experiences a separate realization of the shock. Therefore, the total measure of consumers opting to go out and consume nightlife services is $N = \bar{N} \min\{V(p), 1\}$. That is, N increases with the value of going out up to the point where all consumers choose to go out, at which point $N = \bar{N}$. This feature represents the "vibrancy" aspect of qualitative discussions of nightlife amenities — cities with a wider variety of venues (and therefore higher utility to going out) attract more consumers to go out.

2.1.2 Profit maximization

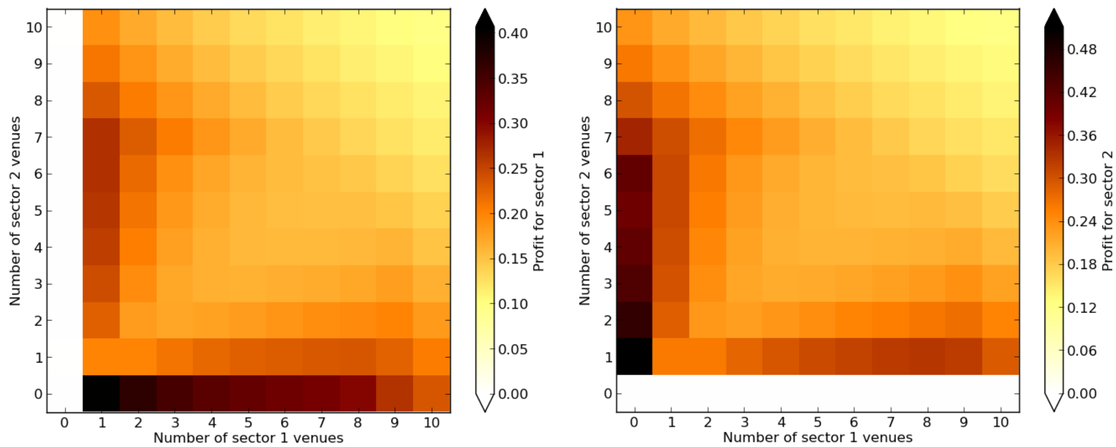
Each venue sets the price of its services to maximize profit. Venues face the demand $q_{\ell i}^D$ (as given by Equation 2) from measure $N = \bar{N} \min\{V(p), 1\}$ consumers. A venue of type ℓ faces a constant marginal cost of production c_ℓ as well as a fixed cost of production κ_ℓ. This gives the following profit maximization problem:

$$\pi_{\ell i} = \max_{p_{\ell i}} \left\{ (p_{\ell i} - c_\ell) \left(\frac{p_{\ell i}}{P_\ell} \right)^{-\rho} \left(\frac{P_\ell}{P} \right)^{-\eta} P^{-1} \bar{N} \min\{V(p), 1\} w - \kappa_\ell \right\} \tag{4}$$

Each venue sets prices taking into account the other venues' prices. Therefore, the equilibrium concept is a Bertrand-Nash equilibrium. Taking the first-order condition and rewriting in terms of $s_{\ell i} = \frac{q_{\ell i}}{\sum_{i'} q_{\ell i'}} = p_{\ell i}^{1-\rho_\ell} P_\ell^{\rho_\ell - 1}$ (the share of demand in sector ℓ going to venue i) and $S_\ell = \frac{\sum_i q_{\ell i}}{\sum_{\ell'} \sum_i q_{\ell' i}} = P_\ell^{1-\eta} P^{\eta-1}$ (the share of total demand going to sector ℓ) yields the following optimal pricing strategy:

$$p_{\ell i} = \begin{cases} \left(1 + \frac{1}{\rho_\ell - \left(\rho_\ell - \left[1 + S_\ell^{\frac{\eta}{\eta-1}} \sum_{\ell'} \left(S_{\ell'}^{\frac{\eta}{\eta-1}} \right)^{-1} \right] \eta \right) s_{\ell i} - 2(\eta-1) S_\ell s_{\ell i} - 1} \right) c_\ell & \text{if } V(p) < 1 \\ \left(1 + \frac{1}{\rho_\ell - (\rho_\ell - \eta) s_{\ell i} - (\eta - 1) S_\ell s_{\ell i} - 1} \right) c_\ell & \text{if } V(p) \geq 1 \end{cases} \tag{5}$$

As all venues in a given sector ℓ are symmetric by assumption, they must set the same prices



(a) Profit in sector 1

(b) Profit in sector 2

Figure 1: Profit by sector in a two-sector example.

in equilibrium. Therefore, $s_{\ell i} = \frac{1}{n_\ell}$:

$$p_{\ell i} = \begin{cases} \left(1 + \frac{n_\ell}{n_\ell(\rho_\ell - 1) - \left(\rho_\ell - \left[1 + S_\ell^{\frac{\eta}{\eta-1}} \sum_{\ell'} \left(S_{\ell'}^{\frac{\eta}{\eta-1}}\right)^{-1}\right]\eta\right) - 2(\eta-1)S_\ell}\right) c_\ell & \text{if } V(p) < 1 \\ \left(1 + \frac{n_\ell}{n_\ell(\rho_\ell - 1) - (\rho_\ell - \eta) - (\eta - 1)S_\ell}\right) c_\ell & \text{if } V(p) \geq 1 \end{cases} \tag{6}$$

Considering Equation 6 over all sectors ℓ gives a system of L equations for the prices over all sectors $\ell \in 1, 2, \ldots, L$. This is not a closed-form solution, as the industry shares $S_1, S_2, \ldots, S_L$ appear on the denominator on the right-hand side and these are a function of the prices. In general, no closed form solution exists for the equilibrium prices. However, the following theorem justifies the use of numerical methods to solve Equation 6 for equilibrium prices.

Proposition 1. *There exists a unique set of prices p^* which solves Equation 6.*

Proof. See Appendix A. □

Figure 1 shows the equilibrium profits for a single venue in a two-sector example as a function of the number of venues in each sector. In these examples, profit is notmonotonic in the number of competitor venues. In general, the model allows for venue profit to increase in the number of venues.

This result also has an intuitive explanation. A greater variety of nightlife options means more consumers' utility exceeds their reservation shock and therefore more consumers choose to consume at the venues. If an additional venue causes enough consumers to opt to go out and consume nightlife that this positive effect on revenue dominates the negative effect of additional competition, then profit for an incumbent venue will rise when a new venue enters the market. That is, the consumer preference for variety represents a positive demand-side agglomeration effect from the venues' point of view. The strength of this effect depends on the CES parameters ρ_ℓ and η — lower elasticity of substitution corresponds to stronger preferences for variety and therefore higher profits for venues which are located near other venues. (Conversely, in the case where the elasticity of substitution is ∞, the venues are indistinguishable from the consumers' point of view and the venue's problem reduces to the standard Bertrand oligopoly.)

However, note that profit will *not* increase indefinitely with the number of venues. Regardless of parameter values the consumer utility of going out will always reach $V(p) = 1$ for sufficiently many venues:

Proposition 2. *There exists some $\bar{n} \in \mathbb{N}$ such that, when $n_\ell \geq \bar{n}$ for $\ell \in 1, 2, \ldots, L$, the equilibrium prices give $V(p) \geq 1$.*

Proof. See Appendix B. □

Once $V(p) = 1$, with higher n_ℓ the equilibrium prices eventually converge to the standard CES pricing strategy $p_{\ell i} = \frac{\rho_\ell}{\rho_\ell - 1} c_\ell$ and (as in the standard CES case) profit declines with additional venues. Accordingly, while the agglomerative benefits in this model may provide higher profits to venues located near other venues, the benefit does not grow until venue density and profits become infinite. Once the neighbourhood is maximally vibrant and everyone who would go out is already going out, the profit no longer grows with the number of venues in the neighbourhood.

Figure 2 shows the corresponding consumer welfare as a function of the number of venues in each sector. Note that this includes not only the consumers who choose to go out, but also the consumers whose reservation utility exceeds the utility of going out. As shown, consumer utility is highest in situations with many venues.

2.2 Dynamic model

The static model presented above describes venue profits as a function of neighbourhood attributes and the number of competitors. I connect this profit function to venue entry and exit data with a dynamic model of entry and exit decisions. In this model, agents observe

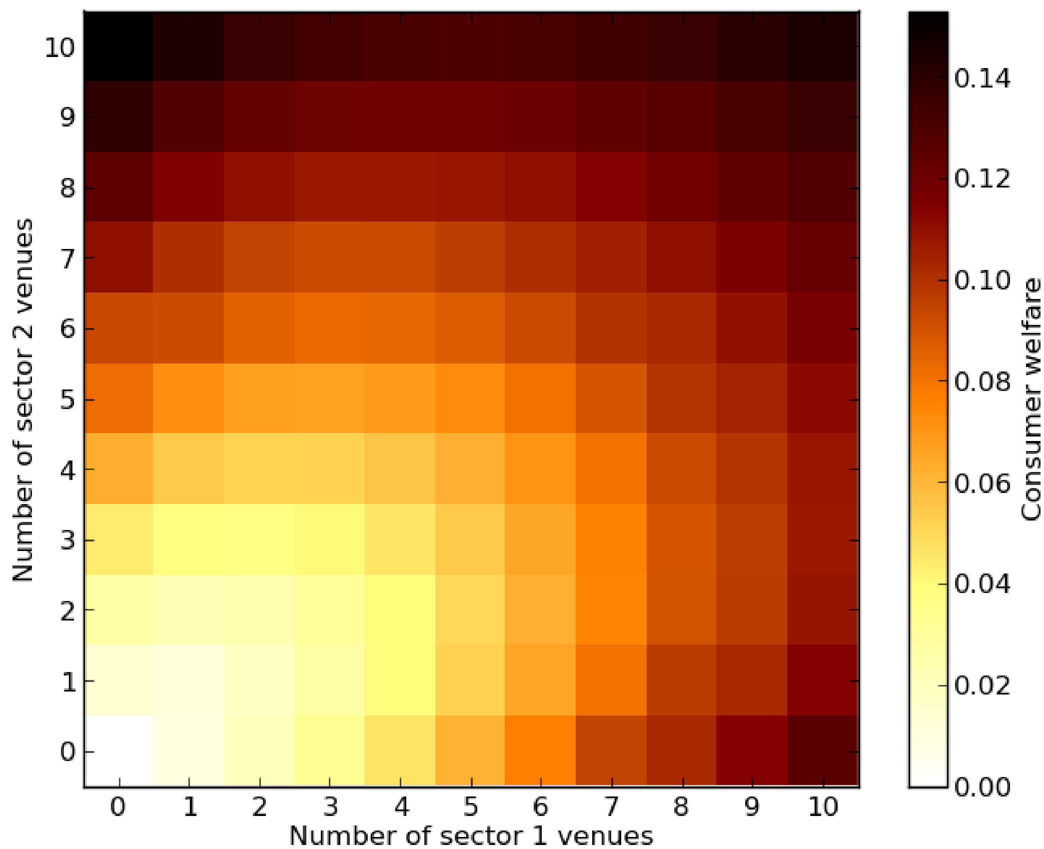


Figure 2: Consumer in a two-sector example. Figure 1 shows the corresponding venue profit.

each others' actions and the state of the environment and make entry and exit decisions as a best response to their beliefs about each others' actions. In equilibrium, these beliefs about each others' actions are consistent; therefore, this is a Markov-Nash equilibrium.

The agents in the dynamic model are the operators of individual venues — potential market entrants and already-operating incumbents. As discussed previously, agents receive opportunities to move in continuous time according to the realization of a Poisson process. Upon receiving an opportunity, potential market entrants make the decision whether to enter or stay out of the market and incumbent venues make the decision whether to continue or leave the market. Once an incumbent leaves the market, they have left the market forever. A potential entrant must pay a sunk cost to enter while an exiting incumbent receives an exit payoff.

As discussed in further detail below, the sunk cost of entry and the exit payoff consist of a deterministic component and a stochastic component. The deterministic component of each agent's shock is mutual common knowledge, while the stochastic component is private knowledge for the agent and realized only once the agent receives a move opportunity. These shocks capture the economic reality that potential may face barriers to entry and owners may receive gains from the sale of capital goods upon exiting the market. As well, they give rise to a nondegenerate probability distribution for entry and exit upon receiving a move opportunity. This allows for the use of observed entry and exit rates to identify profit functions, which is a key aspect of the estimation procedure outlined below.

Agents are assigned to discrete neighbourhoods indexed by m. That is, each entrant has a specific neighbourhood in which it may choose to enter and each incumbent may either continue to operate in its neighbourhood or exit the market[9]. Each neighbourhood has $n_m = (n_{m1}, n_{m2}, \ldots, n_{mL})$ incumbent venues of each type $\ell \in 1, 2, \ldots, L$ as well as ν_ℓ entrants of type ℓ. (As the number of potential entrants is unobservable, I treat this as a parameter to be estimated.) As well, each neighbourhood has some persistent demographic attributes d_m which affect the profit and some persistent regulatory stringency r_m which affects the size of the sunk cost of entry[10]. Potential entrants receive opportunities to enter the market according to a Poisson process with rate parameter α while incumbent venues receive opportunities to exit the market according to a Poisson process with rate parameter α. I assume that agents discount the future at constant rate δ.

Each agent forms its value function based on its consistent belief of other agents' entries and exits as well as its expectations of its own move opportunities. An incumbent venue receives the flow profit π_ℓ as specified by Equation 4. Let ι_ℓ be a vector with 1 as element ℓ and 0 as all other elements — i.e., $n + \iota_\ell$ is the vector of incumbent venues after a new venue of type ℓ enters. The value function for an incumbent venue of type ℓ (as a function of the number of venues n_m, the demographic attributes d_m, and the regulatory conditions

[9] A richer model could allow potential entrants to choose a neighbourhood for entry. However, in this model, the value function for an entrant or incumbent in neighbourhood m would depend on the value function in all other neighbourhoods, as the entry rate in neighbourhood m would depend on the profitability of neighbourhood m relative to other neighbourhoods. Such a rich model would correspond to a much larger state space. Estimation would be infeasible given the available data and computational hardware. These limitations necessitate that I assume each entrant is associated with a particular neighbourhood and must make entry decisions only in that neighbourhood. This assumption may be justified if we assume that entrants have some particular knowledge of local conditions within the neighbourhood.

[10] Suzuki (2013) shows that local land use regulations may represent a significant barrier to entry for new firms.

r_m) is as follows:

$$V_\ell^c(n_m, d_m, r_m) = \left[\delta + \sum_{\ell'} \Big(\nu_{\ell'}\alpha_{\ell'} + n_{\ell'}\lambda_{\ell'}\Big)\right]^{-1} \times \Bigg[\pi\left(n_m, d_m\right) +$$
$$\sum_{\ell'} \Big(\left(n_{\ell'} - I(\ell, \ell')\right) \lambda_{\ell'} \sigma_{\ell'}^x(n_m, d_m, r_m) V_\ell^c(n_m + \iota_{\ell'}, d_m, r_m) + \nu_{\ell'}\alpha_{\ell'}\sigma_{\ell'}^e(n_m, d_m, r_m) V_\ell^c(n_m - \iota_{\ell'}, d_m, r_m)\Big) +$$
$$\lambda_\ell \mathbb{E}\left[\max\left\{V_\ell^c(n_m, d_m, r_m), \psi_\ell^x + \varepsilon_x\right\}\right]\Bigg] \quad (7)$$

In Equation 7, the second line accounts for entries and exits by other agents while the third line accounts for the incumbent's decision to remain or exit conditional on receiving a move opportunity. Note that in the continuous-time environment it is unnecessary to account for the possibility of multiple simultaneous transitions as this is a measure-zero event.

The value function for a potential entrant of type ℓ which has not yet chosen to enter the market is similar, although the potential entrant receives no flow of profit:

$$V_\ell^e(n_m, d_m, r_m) = \left[\delta + \sum_{\ell'} \Big(\nu_{\ell'}\alpha_{\ell'} + n_{\ell'}\lambda_{\ell'}\Big)\right]^{-1} \times \Bigg[0 +$$
$$\sum_{\ell'} \Big(n_{\ell'} \lambda_{\ell'} \sigma_{\ell'}^x(n_m, d_m, r_m) V_\ell^e(n_m + \iota_{\ell'}, d_m, r_m) + \left(\nu_{\ell'} - I(\ell, \ell')\right)\alpha_{\ell'}\sigma_{\ell'}^e(n_m, d_m, r_m) V_\ell^e(n_m - \iota_{\ell'}, d_m, r_m)\Big) +$$
$$\alpha_\ell \mathbb{E}\left[\max\left\{V_\ell^e(n_m, d_m, r_m), V_\ell^c(n_m + \iota_\ell, d_m, r_m) - \psi_e(r_m) + \varepsilon_e\right\}\right]\Bigg] \quad (8)$$

These value functions lead directly to the conditional choice probabilities for venue entry and exit decisions. Conditional on receiving an entry opportunity, a potential entrant will choose to enter (and become an incumbent venue) only if the value of being an incumbent exceeds the value of remaining an entrant less the entry sunk cost. Similarly, conditional on receiving an exit opportunity, an incumbent will exit only if the exit payoff exceeds the value of continuing as an entrant. These entry cost $\psi_e(r) + \varepsilon_e$ and the exit payoff $\psi_x + \varepsilon_x$ consist of deterministic components $\psi_e(r)$[11] and ψ_x plus independent and identically distributed stochastic components ε_e and ε_x. As noted previously, the fixed components of these shocks are mutual common knowledge, while the realizations of the stochastic components are private information for each agent upon receiving a move opportunity. For tractability, I assume Type-I extreme value forms for the stochastic components.

Therefore, conditional on receiving move opportunities, the conditional choice probabil-

[11] To reflect the possibility that local land-use regulation impacts the sunk cost of entry, I allow ψ_e to vary with regulatory stringency r.

ities of entry σ_ℓ^e and exit σ_ℓ^x are as follows:

$$\sigma_\ell^e(n,d,r) = 1 - \exp\left(-\exp\left(-\left(V_\ell^e(n,d,r) - V_c(n,d,r) + \psi_e(r)\right)\right)\right) \tag{9a}$$

$$\sigma_\ell^x(n,d,r) = 1 - \exp\left(-\exp\left(-\left(V_\ell^e(n,d,r) - \psi_x\right)\right)\right) \tag{9b}$$

Recall that α_ℓ and λ_ℓ denote the arrival rate for entry and exit opportunities for entrants and incumbents of type ℓ. Therefore, the entry rate for potential entrants $h_\ell^e(n,d,r)$ and the exit rate for current incumbents $h_\ell^x(n,d,r)$ are as follows:

$$h_\ell^e(n,d,r) = \alpha_\ell \sigma_\ell^e(n,d,r) \tag{10a}$$

$$h_\ell^x(n,d,r) = \lambda_\ell \sigma_\ell^x(n,d,r) \tag{10b}$$

Equation 10 states that the observed entry and exit rates are equal to the rates at which agents receive move opportunities multiplied by the conditional choice probabilities of taking those opportunities. Venue entry and exit rates are observable in the data. In the estimation strategy below, I outline a scheme for connecting the observed entry and exit rates to the flow profit. Differences in venue entry and exit rates between states correspond to differences in the flow profit and the barriers to entry. I use these differences to identify the structural parameters of the model.

2.3 Estimation strategy

I estimate this model using a maximum likelihood strategy following Arcidiacono et al. (2012). The observable outcome of interest in this strategy is the state transition — that is, the entry or exit of a venue. The estimation procedure identifies the values for the structural parameters which maximize the joint likelihood of the wait time between transitions and the type of transition.

The estimation procedure comprises several stages, as follows:

1. Obtain nonparametric estimates $\breve{h}_\ell^e$ and $\breve{h}_\ell^x$ for the observed venue entry and exit rates.

2. Use the estimates $\breve{h}_\ell^e$ and $\breve{h}_\ell^x$ to write the conditional choice probabilities of entry and exit $\hat{\sigma}_\ell^e(n_{mt}, d_m, r_m|\theta)$ and $\hat{\sigma}_\ell^x(n_{mt}, d_m, r_m|\theta)$ in terms of the structural parameters.

3. Find the value of the structural parameters $\hat{\theta}$ which maximizes the likelihood function of the observed transitions.

I estimate a single parameter η for the constant elasticity of substitution between sectors and a single parameter w for the consumer's nightlife budget. For each venue type ℓ, I estimate a separate value for the within-sector constant elasticity of substitution ρ_ℓ, the marginal cost of production c_ℓ, the move arrival rates α_ℓ and λ_ℓ, the number of potential entrants ν_ℓ and the exit payoff ψ^x_ℓ. As discussed in further detail below, I estimate the market size $\bar{N}$, the fixed cost of operation κ_ℓ, and the sunk cost of entry ψ^e_ℓ as a function of demographic and regulatory variables.

At this point, it will be helpful to introduce some additional notation. For a given neighbourhood m, let $t = 1, 2, \ldots, T_m$ index the observed transitions (i.e., entries or exits). Let τ_{mt} be the wait time before transition t, let $n_{mt} = (n_{mt1}, n_{mt2}, \ldots, n_{mtL})$ denote the vector of venues of each type ℓ before transition t, and let $e_{mt\ell}$ and $x_{mt\ell}$ be indicator variables for whether the transition t in neighbourhood m was an entry of type ℓ or an exit of type ℓ. As a slight abuse of notation, let $T_m + 1$ denote the period from the last observed transition to the end of the sample[12]. Then, the log-likelihood of the observed transitions $\{\tau_{mt}, n_{mt}, e_{mt\ell}, x_{mt\ell}\}$ can be written as a function of these entry and exit rates h^e_ℓ and h^x_ℓ as follows:

$$
\begin{aligned}
&LLH\left(\{\tau_{mt}, n_{mt}, e_{mt\ell}, x_{mt\ell}\} \mid h^e_\ell, h^x_\ell\right) = \\
&\qquad \sum_m \Bigg[\sum_{t=1}^{T_m+1} (-\tau_{mt}) \sum_\ell \Big(n_{mt\ell} h^x_\ell(n_{mt}, d_m, r_m) + \nu_\ell h^e_\ell(n_{mt}, d_m, r_m) \Big) + \\
&\qquad\qquad \sum_{t=1}^{T_m} \sum_\ell \Big(x_{mt\ell} n_{mt\ell} \log h^x_\ell(n_{mt}, d_m, r_m) + e_{mt\ell} \nu_\ell \log h^e_\ell(n_{mt}, d_m, r_m) \Big) \Bigg]
\end{aligned}
\tag{11}
$$

Equation 11 gives the joint likelihood of the observed wait time between transitions and the observed type of each transition. Specifically, the first sum expresses the likelihood of the observed wait time between transitions and the second sum expresses the likelihood of the observed type of each transition (conditional on observing a transition). Below, I maximize this joint likelihood to obtain the structural parameters. Taking first-order conditions yields closed-form expressions for the nonparametric entry and exit rates:

$$
h^e_\ell(n, d, r) = \left[\sum_m \sum_{t=1}^{T_m+1} \mathbb{I}_{mt} \left\{ (n, d, r) = (n_{mt}, d_{mt}, r_{mt}) \right\} \tau_{mt} \right]^{-1} \left[\sum_m \sum_{t=1}^{T_m} \mathbb{I}_{mt} \left\{ (n, d, r) = (n_{mt}, d_{mt}, r_{mt}) \right\} e_{mt\ell} \right]
\tag{12a}
$$

[12]In this last period, the state after the next transition is clearly unobservable. However, the duration of the wait before a transition is itself informative, and therefore included in the likelihood function.

$$h_\ell^x(n,d,r) = \left[\sum_m \sum_{t=1}^{T_m+1} \mathbb{I}_{mt}\left\{(n,d,r) = (n_{mt},d_{mt},r_{mt})\right\}\tau_{mt}\right]^{-1} \left[\sum_m \sum_{t=1}^{T_m} \mathbb{I}_{mt}\left\{(n,d,r) = (n_{mt},d_{mt},r_{mt})\right\} x_{mt\ell}\right] \tag{12b}$$

In Equation 12, $\mathbb{I}$ denotes the indicator function. The entry and exit rates in Equation 12 can be estimated directly from the data. Denote the results of this estimation by $\breve{h}_\ell^e$ and $\breve{h}_\ell^x$.

Next, I use these first-stage estimates $\breve{h}_\ell^e$ and $\breve{h}_\ell^x$ to write the value functions in terms of structural parameters[13]. Arcidiacono et al. (2012) shows that the agents' value functions can be written in terms of h_ℓ^e and h_ℓ^x, the move arrival rate parameters α and λ, and the entry sunk cost and exit payoff ψ_ℓ^e and ψ_ℓ^x:

$$V_\ell^e\left(n,d,r \mid h_\ell^e, h_\ell^x, \alpha, \lambda, \psi_\ell^e, \psi_\ell^x\right) = \psi_\ell^x - \psi_e(r) + \log\frac{1-\lambda_\ell^{-1}h_\ell^x(n,d,r)}{\lambda_\ell^{-1}h_\ell^x(n,d,r)} + \log\frac{1-\alpha_\ell^{-1}h_\ell^e(n,d,r)}{\alpha_\ell^{-1}h_\ell^e(n,d,r)} \tag{13a}$$

$$V_\ell^c\left(n,d,r \mid h_\ell^e, h_\ell^x, \alpha, \lambda, \psi_\ell^e, \psi_\ell^x\right) = \psi_\ell^x + \log\frac{1-\lambda_\ell^{-1}h_\ell^x(n,d,r)}{\lambda_\ell^{-1}h_\ell^x(n,d,r)} \tag{13b}$$

Recall that $\alpha_\ell^{-1}h_\ell^e$ is the probability of entry conditional on receiving a move opportunity while $\lambda_\ell^{-1}h_\ell^x$ is the probability of exit conditional on receiving a move opportunity. The value of an agents' decision conditional on receiving a move opportunity can be written in terms of the same objects[14]:

$$\mathbb{E}\left[\max\left\{V_\ell^e(n,d,r), V_\ell^c(n+\iota_\ell,d,r) - \psi_e(r) + \varepsilon_e\right\} \mid h_\ell^e, h_\ell^x, \alpha, \lambda, \psi_\ell^e, \psi_\ell^x\right] = -\log(1-\alpha_\ell^{-1}h_\ell^e(n,d,r)) + \gamma \tag{14a}$$

$$\mathbb{E}\left[\max\left\{V_\ell^c(n,d,r), \psi_\ell^x + \varepsilon_x\right\} \mid h_\ell^e, h_\ell^x, \alpha, \lambda, \psi_\ell^e, \psi_\ell^x\right] = -\log(1-\lambda_\ell^{-1}h_\ell^x(n,d,r)) + \gamma \tag{14b}$$

Substituting the first-stage estimation results $\breve{h}_\ell^e$ and $\breve{h}_\ell^x$ into Equations 13 and 14 gives consistent estimates for the value functions. Substituting these estimates into the right-hand sides of Equation 7 and 8 yields expressions for the value functions in terms of the structural parameters (including the structural parameters of the profit function). Substituting these structural expressions for the profit function into Equation 9 gives the choice probabilities for venue entry and exit (conditional on receiving a move opportunity) as a function of the

[13] I could also address this stage using value function iteration on Equations 7 and 8. However, the strategy discussed here is much faster and yields exact results.

[14] In Equation 14 $\gamma \approx 0.5772156649$ is the Euler constant. This constant arises from the integration over the stochastic components of the entry cost and exit payoff. It is specific to the assumed Type-I extreme value functional form of these shocks.

structural parameters. Denote these structural conditional choice probability estimates as $\hat{\sigma}^e_\ell(n_{mt}, d_m, r_m|\theta)$ and $\hat{\sigma}^x_\ell(n_{mt}, d_m, r_m|\theta)$ where θ is the vector of parameters including the move opportunity rates α and λ, the number of potential entrants ν, and all parameters of the profit function. This yields the following expression for the log-likelihood of the observed transitions in terms of the structural parameters:

$$
\begin{aligned}
&LLH\left(\{\tau_{mt}, n_{mt}, e_{mt\ell}, x_{mt\ell}\} \mid \theta\right) = \\
&\quad \sum_m \Bigg[\sum_{t=1}^{T_m+1} (-\tau_{mt}) \sum_\ell \Big(n_{mt\ell}\lambda_\ell \hat{\sigma}^x_\ell(n_{mt}, d_m, r_m|\theta) + \nu_\ell \alpha_\ell \hat{\sigma}^e_\ell(n_{mt}, d_m, r_m|\theta) \Big) + \\
&\quad \sum_{t=1}^{T_m} \sum_\ell \Big(x_{mt\ell} n_{mt\ell} \log \lambda_\ell \hat{\sigma}^x_\ell(n_{mt}, d_m, r_m|\theta) + e_{mt\ell}\nu_\ell \log \alpha_\ell \hat{\sigma}^e_\ell(n_{mt}, d_m, r_m|\theta) \Big) \Bigg] \qquad (15)
\end{aligned}
$$

I solve numerically for the parameter vector $\hat{\theta}$ which maximizes the structural log-likelihood as specified by Equation 15. This estimate $\hat{\theta}$ forms the basis of the empirical results of this study.

It remains to discuss the parameterization of $\bar{N}$, κ_ℓ, and ψ^e_ℓ. I use log-linear specifications in demographic conditions d to estimate $\bar{N}$ and κ_ℓ:

$$\bar{N}(d) = \exp(\theta_{\bar{N}o} + \theta_{\bar{N}d} d) \qquad (16a)$$

$$\kappa_\ell(d) = \exp(\theta_{\kappa\ell} + \theta_{\kappa d} d) \qquad (16b)$$

For the sunk cost of entry ψ^e_ℓ, I use a long-linear specification in regulatory conditions r:

$$\psi^e_\ell(r) = \exp(\theta_{\psi o} + \theta_{\psi r} r) \qquad (17)$$

For the sake of tractability, I discretize all persistent state variables (the neighbourhood attributes d_m and the regulatory stringency r_m into five evenly spaced bins. When estimating the transition rates in Equation 12, I smooth between bins using a multidimensional Guassian kernel with optimal bandwidth. I set the future discount parameter δ at 0.9 per year. I calculate the standard errors from the score function of the likelihood.

2.4 Identification of colocation benefits

The model outlined above ascribes differences in venue entry and exit rates as a function of other venues in the neighbourhood (holding constant regulation, demographic attributes, and the build environment) to consumer preferences for variety. This may initially seem to be a strong assumption as in general firms in the same industry may benefit from colocation for reasons other than consumer preferences. However, as discussed above, consumer preferences for variety are likely to be particularly strong in the context of the nightlife industry. Moreover, I argue that other sources of agglomerative benefits are unlikely to be as important here as in other industries.

One immediate alternative hypothesis is that venues may gain some production cost advantage to colocation. However, as noted by Samadi (2012), the average nightlife venue's costs are unlikely to vary significantly within a city. Specifically, the average venue's spending on wages, alcohol purchases, and utilities constitutes 70.0% of its total spending, while rent accounts for only 3.1%. (The remainder is accounted for by depreciation and other expenses.) While alcohol purchases (which account for 45.6% of spending) may seem to offer possible cost advantages if distributors offer discounts to nearby venues, this does not appear to be the case. Wirtz Beverage Illinois (one of the largest distributors in Chicago) makes deliveries within the city proper based on a flat minimum order Wirtz Beverage Illinois (n.d.).

An alternative explanation for colocation studied by Toivanen and Waterson (2005), Yang (2013), and Shen and Xiao (2014) is that firms learn about the profitability of a given location by observing each others' success. However, these studies generally consider learning effects for firms seeking to open in new cities. Learning seems as though it would be less of a concern in the current context. Most venues are owned by a firm that owns no other venues; insofar as the owners of these firms are likely to be located in Chicago, their knowledge of local conditions is likely strong[15]. The cost of acquiring information is likely relatively low in Chicago, which is a very large and prominent city with well-documented distinct neighbourhoods. Moreover, as shown in Figure 3, the spatial distribution of venues covers the densely populated areas of the city. Accordingly, the ability to learn about very local conditions from other venues' experiences appears to be fairly well-distributed across the city.

Holmes (2011), Arcidiacono et al. (2012), Igami and Yang (2014), and others have discussed the role of stragetic siting by retail chains as a possible explanation for observed firm location patterns. However, this would not seem to be relevant in the current context. As discussed in further detail below, concentration in the nightlife industry in Chicago is very low. The overwhelming majority of venue licenses are held by firms which hold no other

[15] Chinco and Mayer (2014) provide evidence for strong informational advantage of local investors in the housing market.

venue licenses.

As Datta and Sudhir (2013) note, failing to account for local heterogeneity and zoning leads to misspecification errors. These may overstate the importance of agglomerative effects. However, in this paper, I account for neighbourhood heterogeneity and regulatory conditions directly.

In the context of nightlife specifically, consumer demand may be higher in neighbourhoods with more foot traffic or higher-quality commercial districts. These unobservable neighbourhood attributes could lead to colocation of venues, which the model would misattribute to consumer preference for variety. As discussed in further detail below, I address this possibility directly as a robustness check using the locations of Starbucks coffee shops as a proxy for these unobservable neighbourhood attributes. I find no evidence of a systematic relationship between Starbucks locations and nightlife venue profitability.

Accordingly, it seems reasonable to attribute the effect of the number of competitors on firm profitability to consumers' preference for variety. Not only is consumer preference for variety likely to be particularly relevant in the nightlife industry (where consumers prefer the ability to visit several venues with low travel cost) but also the other potential agglomerative effects on firm profitability seem less significant.

3 Data and industry details

To estimate the structural model outlined above, I use data from Chicago. To explain how the data set corresponds with the model outlined above, I discuss the specific conditions of the Chicago nightlife industry in some detail.

3.1 Nightlife venues

For information on nightlife venues, I use business license data from the City of Chicago Data Portal, which provides information on the new, renewed, and expired business licenses from January 2006 through July 2014. Representative examples of nightlife venues in my sample include "Ted's Firewater Saloon", "Las Vegas Nite Club", and "Zero Degrees Karaoke Bar". I assume that a new liquor license represents a new entrant while an expired liquor license represents an incumbent exiting the market. This data set contains information on liquor licenses (both for establishments which primarily serve alcoholic beverages and establishments with "incidental" consumption of alcohol) as well as an indication of whether the licensee's operations including music or dance and an indication of whether the licensee

	Start of sample	Entries	Exits
Amusement only	93	33	54
Drinks only	643	134	268
Drinks and amusement	56	31	23
Drinks and music	85	7	31

Table 1: Summary statistics for the number of venues of each type in the sample.

is a “Public Place of Amusement” . (Public Places of Amusement include theatres, concert halls, bowling alleys, pool halls, karaoke bars, and arcades as well as nightclubs and similar facilities (Chicago City Council, 1990*a*).)

In this study I examine consumer’s preference for variety among similar venues as well as their preference across different types of venues. I use characteristics of venues’ business licenses to assign them to separate sectors. Specifically, I define the following four categories of nightlife venues:

- Venues which have Public Place of Amusement licenses with either no liquor licenses or licenses only for “incidental” consumption (“Amusement only”)
- Venues with alcohol licenses which do have Public Place of Amusement licenses and which do not have music/dance licenses (“Drinks only”)
- Venues with alcohol licenses and Public Place of Amusement licenses but not music and dance licenses (“Drinks and amusement”)
- Venues with alcohol licenses and music/dance licenses and possibly also Public Place of Amusement licenses (“Drinks and music”)

While the data set includes restaurants and mobile food vendors, I do not include these categories in the estimation. Restaurants may not contribute as strongly to nightlife amenities and they are frequently owned by chains which may optimize according to a very different strategy than the one described above. I am unable to sensibly assign mobile food vendors to a particular neighbourhood due to their mobile nature.

Figure 3 shows the geographical distribution for venues across Chicago. As shown, all venue types are widely distributed across the city. Table 1 shows summary statistics for the venues in the sample.

To ensure that these type from liquor licensing data correspond to real-world categories of

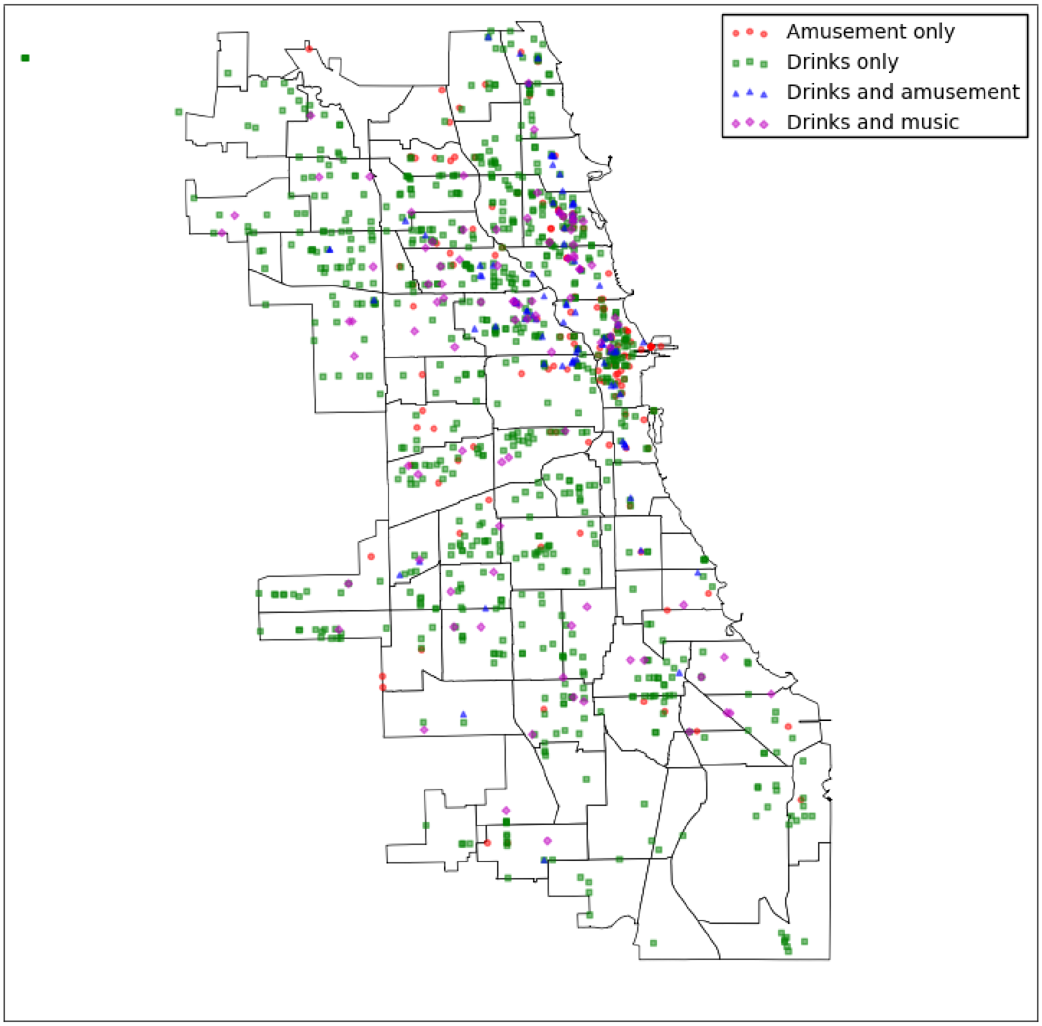


Figure 3: Geographical distribution of venues within Chicago.

venues, I match the venues to Yelp listings[16]. The Yelp API does not return businesses which have already closed and I am unable to match businesses which operate under substantially different names than their names in the license data. Accordingly, I can identify only 19% of the businesses on Yelp.

I use a multinomial logit regression to examine how closely the Yelp categories and

[16]Specifically, I search for each venue by latitude and longitude using the Yelp API and then match business names in the licensing data to business names on Yelp using pattern matching. The pattern matching algorithm does not require an exact match. For example, I match the venue "Checker Board Lounge" from the business license data with the Yelp listing "Checkerboard Lounge" and the venue "Six Penny B P" from the business license data with the Yelp listing "Six Penny Bit". Yelp assigns categories to businesses, such as "Buffets" or "Sports Bars" or "Massage". An individual business may be assigned multiple categories.

	Drinks only	Drinks and amusement	Drinks and music
Intercept	0.993^{**}	-1.474^{**}	-0.998^{*}
	(0.404)	(0.665)	(0.601)
Dance Clubs	-0.273	2.485^{**}	2.096^{*}
	(1.207)	(1.226)	(1.223)
Pubs	16.864^{***}	0.742^{***}	16.997^{***}
	(0.357)	(0.000)	(0.357)
Lounges	2.297^{**}	2.947^{**}	2.222^{*}
	(1.086)	(1.217)	(1.220)
Music Venues	-0.053	1.742	0.570
	(1.185)	(1.262)	(1.355)
Sports Bars	17.685^{***}	17.387^{***}	17.256^{***}
	(0.444)	(0.644)	(0.612)
Bars	18.471^{***}	18.375^{***}	17.678^{***}
	(0.361)	(0.477)	(0.485)
Log Likelihood	-141.689	-141.689	-141.689
Deviance	283.379	283.379	283.379
Num. obs.	812	812	812

Table 2: Results of a multinomial logit regression of the licensing categories on the most frequently-assigned Yelp categories. The regression sample is the set of venues which matched with Yelp businesses. The omitted licensing category is the "Amusement only" category. $*$, $**$, and $***$ denote statistical significance at the 10%, 5%, and 1% levels.

liquor licensing categories coincide. Specifically, I regress the liquor licensing categories on indicator variables for whether Yelp assigned the venues to the six most commonly-assigned Yelp categories in the sample: "Dance Clubs", "Pubs", "Lounges", "Music Venues", "Sports Bars", and "Bars". Table 2 shows the results of this regression. As shown, the Yelp categories are generally significant predictors of the liquor licensing categories. In particular, many of the coefficients are large in magnitude and significantly different from zero, venues which Yelp assigns to the "Dance Club" category are much less likely to be in the "Drinks only" license category, and venues which Yelp identifies as "Pubs" are much less likely to be in the "Drinks and amusement" license category. Therefore, the comparison with Yelp suggests that the categories based on business licenses constitute a reasonable division of the venues into categories that would be relevant to consumers.

It is worth emphasizing that the licensing data set suggests the industry has a very low level of concentration. With fewer than a dozen exceptions (e.g. multiple Four Seasons hotels with their own bars) the license for each venue is held by a different firm. Matching firm names for licenses in the data set gives a Herfindahl index of 0.00694. This is consistent with the description of Samadi (2012), who describes the market share concentration as “low” and notes that the nightlife industry “in general, consists of small businesses, with few major operators and many being family owned and operated”[17]. Therefore, it seems reasonable to treat the individual venue as the decision-making unit.

3.2 Neighbourhoods

To discretize the city into separate nightlife markets, I use the community area boundaries developed by the University of Chicago's Local Community Research Committee in the 1920s to provide a more salient alternative to census tracts (Seligman, 2004). These 77 neighbourhoods are based on natural boundaries and still frequently used by planners and real estate agents; many also correspond to popular usage. Inevitably, any partition scheme for discretizing a city into neighbourhoods is somewhat artificial. However, these neighbourhood boundaries appear to provide a reasonable approximation to actual geographical segmentation of the market for nightlife venues. Not only are these boundaries used for city planning and public service (e.g., the Chicago Neighbourhood Stabilization housing market program organizes its activities by neighbourhood), but they are also frequently used in real estate listings as well as media reports comparing Chicago neighbourhoods (Rodkin, 2010; Taylor, 2013; Moser, 2013). Accordingly, in terms of spatial units which consumers and venues might use, community areas seem like a reasonable choice. Many authors in various public policy literatures have also adopted the community area as a unit of analysis (Wilson and Daly, 1997; Shah, Whitman and Silva, 2006; Illinois Assisted Housing Action Research Project, 2010).

Below, I explore alternate definitions of neighbourhood boundaries as a robustness check. I find that results for consumer preference for variety are not sensitive to the specific boundaries between neighbouroods.

[17] It appears that this low concentration is broadly representative of other large cities. While none offer a panel of similar length to the Chicago data, the business license data set for currently-operating businesses in the category “Drinking places (alcoholic beverages)” from San Francisco Data suggests a Herfindahl index of 0.0146 while the 2012 business license data set from data.seattle.gov for business in the category “Drinking places (alcoholic beverages)” suggests a Herfindahl index of 0.0108. These values are higher than the very low concentration in Chicago, but still reflect an industry composed of many small firms.

3.3 Regulatory environment

Venues in Chicago face citywide regulatory barriers to entry as well as very local within-city regulation. Citywide regulatory barriers include a licensing fee of at least $4,400 (with additional fees for patios and later hours of operation) and applications for new licenses must include extensive documentation as well as liquor liability insurance and criminal background checks for investors, corporate officers, and managers (Chicago Department of Business Affairs and Consumer Protection, n.d.). These represent significant sunk investment costs, particularly since liquor license applications are sometimes rejected (Kindelsperger, 2011; Maidenberg, 2013; Morgan, 2013) and therefore investors may be reluctant to contribute to opening a new venue. Moreover, the regulatory process may introduce unpredictable and potentially costly delays to the process. At the local level, Chicago has a distinct system of liquor license regulation which features two forms of restriction on liquor licensing: bans and moratoria (Chicago Department of Business Affairs and Consumer Protection, n.d.). Bans prohibit outright the issuance of liquor licenses; all incumbent venues must exit when a new ban is enacted. Moratoria place restrictions on the locations of new primary liquor licenses — most importantly, a moratorium sets a minimum distance from existing primary liquor licenses.

Bans are instituted by popular vote in precinct-level[18] referenda which take place alongside other elections (Illinois General Assembly, 1934). The legislation to empower voters to enact outright bans on liquor licenses was enacted in 1934 immediately after the end of Prohibition, when many state legislatures were granting local control over liquor purchase and consumption (Strumpf and Oberholzer-Gee, 2000). In the modern context, these referenda are unique to Chicago among large American cities. These referenda take place at a very local level; in the forty referenda since 2000, the total ballot count has averaged 241, and none has returned more than 490 ballots. The ban can be repealed, but it seems this rarely occurs. Only one of the forty referenda since 2000 considered a potential repeal, and this referendum was defeated.

It appears that venues regard the referendum process as beyond their ability to influence. Incumbent venues affected by dry precinct bans tend to accept a referendum once it is announced (Cawthon, 1998; Mitchell, Moore and Yousef, 2011; Byrne, 2012). Potential entrants are often deterred very early in the entry process by potential referenda regardless of support from local politicians and institutions (Lambert, 2008; Mitchum, 2008; Lam, 2008). These media reports suggest that venue owners regard attempts to influence proceedings

[18]Chicago is divided into fifty wards, which are subdivided into over two-thousand precincts.

as ineffective. An attorney with thirty years experience representing businesses which sell liquor in Chicago offered the following description of the precinct-level liquor referendum process (Byrne, 2012):

> A vote-dry referendum is like a legal assassination for any business, whether deliberately targeted or accidentally in its path. With rare exceptions in the last 30 years, a business will be voted dry with clear majorities.

Liquor license moratoria are established by decisions of city council (Chicago City Council, 1990*b*). Moratoria also impact liquor license at a very local scale; some moratoria apply only to one side of a particular street. Within a moratorium zone, new liquor licenses are prohibited within 400 feet of existing licenses. Existing licenses may only be transferred to immediate family members, business partners, or inheritors. If a previously-licensed site loses its license, any attempt to open a new venue on the same premises faces steep regulatory hurdles, including the written consent of the majority of registered voters within a 500-foot radius. Accordingly, the license moratorium drastically increases the cost of market entry.

The City of Chicago Data Portal provides information on the locations of dry precincts and local moratoria. The local shares of dry precincts and local moratoria change only slightly over the sample period (predominantly in a few already heavily-regulated neighbourhoods with few venues). Accordingly, I use the average level of regulatory stringency over the sample period. While time-varying regulatory stringency would be possible in this empirical framework, including variation in regulation substantially would increase the size of the state space while providing minimal additional information about venues' decisions.

In addition to the moratoria and dry precincts, municipal noise regulations prohibit liquor licenses within 100 feet of schools, libraries, churches, and certain categories of businesses (Chicago City Council, 1990*c*). The City of Chicago Data Portal provides information on the locations of schools and libraries, as well as the list of institutions given exemptions from water charges. I infer the locations of churches and similar religious edifices from the names of institutions granted exemptions[19]. As these restrictions are virtually indistinguishable from the dry precincts, I include these with dry precincts as a single form of regulation.

Figures 4a and 4b show the proportion of each neighbourhood covered by liquor license moratoria and dry areas. Most neighbourhoods are less than 5% covered by moratoria, while

[19] In particular, I assume that any institution granted an exemption with "church", "temple", "masjid", "synagogue", "mosque", "tabernacle", or a similar term in its name is a religious edifice near which new liquor licenses are prohibited.

several are over 50% covered by dry precincts.

In this study, I construct a model which captures the effects of these regulations on nightlife venues. Precinct-level bans and license moratoria reduce the available real estate for nightlife venues and therefore make it more difficult to find a venue site. In the model, this raises the cost of entry for potential entrants. Moreover, the presence of positive effects of venue colocation on profit complicates the dynamic response of industry to any given policy change; if more stringent policy causes some venues to exit the market, nearby venues benefit from the reduced competition but also may lose customers due to reduced density of nearby venues.

3.4 Neighbourhood attributes

Local demographic and infrastructure characteristics may impact venue profitability. To account for this, I obtain tract-level data from the 2010 US Census as well as demographic data from the 1% sample of the American Community Survey (ACS) through the IPUMS database(Ruggles et al., 2010). The ACS data contains geographic specification to the level of the Public Use Microdata Area (PUMA), which is a Census designation for a geographical region of approximately 100,000 residents. I match the tract-level and PUMA-level data to the community areas using GIS software. Table 3 shows summary statistics for neighbourhood attributes.

Ideally, the estimation would condition on all these variables. However, this would substantially increase the dimensionality of the state space and create a challenge for the numerical algorithms used for likelihood maximization. Moreover, many of these neighbourhood attributes are closely correlated. I address this by considering four principal components of the data. Table 4 shows the loading factors for the four principal components. These four components collectively explain 93% of the variance between neighbourhoods. The remaining components account for a much smaller share of the variance. The first principal component primarily corresponds to dense areas near the central business district while the second principal component primarily corresponds to poorer and less dense areas further from the city centre. The neighbourhood attributes are summarized graphically in Figure 4.

	Mean	Std. dev.	Min	Max
Transit stations	1.62	2.68	0	18
Pop. dens. (km^2)	770.04	525.41	125.94	2808.52
Age 20–34 (%)	24.51	5.70	17.80	47.50
Nonfamily (%)	10.03	2.90	4.89	18.97
HH with children (%)	12.52	1.74	6.02	17.11
Renters (%)	44.68	12.38	19.87	79.25
African-American (%)	26.93	27.61	2.27	98.10
Latino/Hispanic (%)	33.39	22.77	1.54	85.54
HH income ($1000)	62.77	20.18	35.41	117.42
HH income $\leq$ 25k (%)	29.69	9.62	13.18	47.07
HH income $\geq$ 100k (%)	19.49	9.29	6.86	39.76
Poverty (%)	23.48	9.34	7.16	42.09
Detached housing (%)	38.05	23.45	4.23	86.12
$>$ 50 unit housing (%)	9.04	15.15	0.47	61.30
Pre-1990 housing (%)	90.76	8.34	60.15	97.06
Dry area (%)	12.39	18.48	0.02	73.45
Moratorium area (%)	1.15	1.48	0.00	9.06

Table 3: Summary statistics for the 77 neighbourhoods in the sample. The last two rows are regulatory variables which are not included in the principal component analysis but rather included directly.

4 Results and discussion

In the discussion of the empirical results, I focus on consumer preferences for variety and the parameters determining venues' entry and exit decisions. Appendix C shows the full set of estimated parameter values including the impacts of demographic attributes on the parameters of the profit function. Figure 5 shows the first-stage nonparametric entry and exit rates $\breve{h}^e_\ell$ and $\breve{h}^x_\ell$ on which the structural estimates are based. As shown, all venue types have a wide range of entry and exit rates across states.

4.1 Parameter estimates

Table 5 shows the estimated CES parameters for consumer preference across venues. As shown, the elasticity of substitution between sectors η is very low, which indicates a very strong preference for variety between sectors. The elasticity of substitution within sectors varies widely. Consumers have a particularly strong preference for variety among "Drinks only" venues (e.g., bars without live music and taverns) and a less-strong preference for va-

Principal component	1	2	3	4
Age 20–34 (%)				
Nonfamily (%)				
HH with children (%)				
Renters (%)				
African-American (%)			-0.459	-0.654
Latino/Hispanic (%)			0.409	0.316
Income $\leq$ 25k (%)			0.229	-0.107
Income $\geq$ 100k (%)			-0.181	0.17
Poverty (%)			0.213	
Detached housing (%)	-0.197		-0.235	0.126
$>$ 50 unit housing (%)	0.12			0.228
Pre-1990 housing (%)				-0.124
HH income ($1000)	0.112		-0.647	0.567
Transit stations	0.961			
Pop. dens. (km^2)		-0.988		
Cum. share of variance	0.444	0.763	0.863	0.932

Table 4: Factor loadings for principal component analysis together with the cumulative share of variance explained by the principal components.

riety among "Drinks and music" venues (e.g., bars with live music and performance venues).

Insofar as I estimate these results based on a CES utility function, they are broadly comparable with other results in the international trade and urban literatures that examine consumer preference for variety[20]. The estimate for the constant elasticities of substitution between "Drinks and music" venues is close to the elasticity of substitution in the range of 8.4–8.8 for restaurants reported by Couture (2014). Meanwhile, the elasticity of substitution between "Drinks only" venues is very low — the value of 2.15 is below the first percentile of goods reported in Broda and Weinstein (2010) and comparable to the elasticity of substitution between varieties for highly variety-specific goods such as coffee, automotive parts, and footwear in Broda and Weinstein (2006). The elasticities of substitution for the other two venue types are more comparable to the 5^{th}-25^{th} percentile of elasticities for consumer goods reported in Broda and Weinstein (2010).

These results suggest a very strong preference for variety in nightlife compared to other consumption goods and services, particularly among bars, taverns, and similar venues without music, dancing, or other amusement. (Below, I quantify this preference by assessing the

[20]However, as noted previously, the consumers' reservation shock is novel to this model and therefore the interpretation of these elasticities is not precisely identical to others in the literature .

Elasticity	Symbol	Estimate
Between sectors	η	2.04
		(1.57×10^{-4})
Amusement only	ρ_1	4.90
		(5.53×10^{-4})
Drinks only	ρ_2	2.15
		(9.79×10^{-5})
Drinks and amusement	ρ_3	3.56
		(3.89×10^{-3})
Drinks and music	ρ_4	7.96
		(1.09×10^{-4})

Table 5: Maximum likelihood estimation results for the CES parameters η and ρ_ℓ. Standard errors in parentheses.

marginal impact of a new venue on consumer welfare.) This strong preference for variety may indicate a consumer preference for the ability to "bar-hop" between many venues of this type. As well, this may reflect an ability by venues without music and and dance licenses or Public Place of Amusement licenses to differentiate themselves in some other unobservable attributes (e.g. décor or types of beverages offered).

Table 6 shows the arrival rates for agents to enter and exit the market. Entry opportunities arise most frequently for the "Drinks only" sector, followed closely by the "Drinks and amusement sector". The other sectors experience fewer opportunities to enter the market. Meanwhile, incumbent venues face opportunities to exit the market at a low frequency (on the order of once per year) across all sectors. This may reflect the timescale of leases, supplier agreements, or other contractual obligations, or it may reflect a low rate of arrival for preferable outside opportunities for nightlife venue operators.

In the dynamic model, the sunk cost of entry and the payoff of exit consist of a deterministic component plus a stochastic component. Table 7 shows the estimated values for the logarithm of the deterministic component of the sunk cost and the exit payoff. These values are denominated in model units. I convert to dollar values below. As shown, the barriers to entry are quite high compared to the payoff from exit.

In Table 7, I also report the effect of dry precincts and moratoria on the barriers to entry. As I estimate the deterministic component of the barrier to entry as a log-linear function of the prevalence of regulation, these should be interpreted as elasticities. Specifically, a 1% increase in dry precincts in a neighbourhood raises the barrier to entry by 0.47% while a 1% increase in moratoria in a neighbourhood raises the barrier to entry by 0.11%. As shown in

Move arrival rate		Symbol	Estimate
Entry	Amusement only	α_1	4.00×10^{-3}
			(6.19×10^{-6})
Entry	Drinks only	α_2	9.05×10^{-1}
			(6.33×10^{-4})
Entry	Drinks and amusement	α_3	7.18×10^{-1}
			(1.30×10^{-3})
Entry	Drinks and music	α_4	1.48×10^{-2}
			(9.16×10^{-4})
Exit	Amusement only	λ_1	5.08×10^{-3}
			(1.41×10^{-10})
Exit	Drinks only	λ_2	9.03×10^{-3}
			(1.29×10^{-6})
Exit	Drinks and amusement	λ_3	2.31×10^{-3}
			(2.06×10^{-6})
Exit	Drinks and music	λ_4	2.10×10^{-3}
			(1.89×10^{-8})

Table 6: Maximum likelihood estimation results for the move arrival rate parameters α_ℓ and λ_ℓ. All values are measured in days^{-1}. Standard errors in parentheses.

Figure 4a, some neighbourhoods are over 60% dry precincts; therefore the estimation results suggest that this poses a substantial deterrent to entry.

These estimated parameters are all in terms of model units, which are determined by the normalization condition on the reservation utility shock $\max\{V^*\} \equiv 1$. To understand these parameter values in terms of policy implications, it is useful to express these terms in dollar values. According to Samadi (2012), the average revenue for a nightlife venue in the United States is $345,121 annually. I assume that this value is representative for venues which only serve drinks, which is the most-numerous venue category in the sample and which seems likely to be most representative of the national average. As well, I assume that 3.6% of revenue is profit as suggested in Samadi (2012) is a representative value for my sample. This suggests a profit of $12,424 annually[21]. Given the discount factor of 0.9 per year, this indicates that (in a hypothetical static environment) the net present value of an incumbent venue is on the order of $124,240. The median continuation value across all states for "Drinks only" venues is 1.24. Therefore, one model unit is approximately $99,810.

This conversion factor allows me to assign dollar values for the sunk cost of entry and

[21]Specifically, Samadi (2012) notes that profit margins can be as high as 59/7%, but 3.6% is the average. This broad dispersion suggests that any dollar values should be interpreted as generally indicative rather than as precise estimates.

	Parameter	
Entry cost	Amusement only baseline	2.11
		(5.94×10^{-4})
	Drinks only baseline	2.17
		(2.87×10^{-4})
	Drinks and amusement baseline	2.11
		(1.89×10^{-4})
	Drinks and music baseline	1.81
		(6.96×10^{-5})
	Role of dry precincts	0.470
		(1.54×10^{-3})
	Role of moratoria	0.106
		(1.88×10^{-4})
Exit payoff	Amusement only	-4.01
		(1.17×10^{-4})
	Drinks only	-4.06
		(1.96×10^{-4})
	Drinks and amusement	-2.76
		(2.71×10^{-5})
	Drinks and music	-3.23
		(5.6×10^{-5})

Table 7: Maximum likelihood estimation results for the logarithm of deterministic component of the sunk cost of entry and the exit payoff. The "baseline" entry cost reflects the entry cost in the absence of local regulation. Standard errors in parentheses.

the payoff from exit. Specifically, I use the parameter estimates from Table 7 to find the deterministic component and then add the median value of the stochastic component[22] then convert from model units to dollars using the factor suggested by the results in Samadi (2012). Table 8 shows the resulting estimates. In general, the parameter estimates suggest barriers to entry on the order of several hundred thousand dollars. These are high barriers to entry which represent several years' profit in most cases. Accordingly, potential entrants likely only choose to enter when they receive a particularly favourable value for the stochastic component of the sunk cost of entry[23]. These results suggest that barriers to entry may

[22]Given the extreme-value functional form of the shocks, the median value of the stochastic component is $-\log\log 2$.

[23]However, while these values appear high, they are comparable in magnitude to costs discussed in the popular media. Ingram (n.d.) suggests initial improvements to the building when opening a nightclub cost \$18,000 to \$65,000, sound equipment can cost \$50,000 to \$300,000, and the lease for the facilities will generally exceed \$10 per square foot. As well, Ingram (n.d.) notes that the total cost of acquiring a liquor license can range as high as \$1 million depending on the jurisdiction. As noted previously, venues in Chicago face an

	Value (thousands of dollars)	
Entry cost	Amusement only baseline	862 [861, 863]
	Drinks only baseline	943 [943, 944]
	Drinks and amusement baseline	892 [891, 892]
	Drinks and music baseline	670 [670, 670]
Exit payoff	Amusement only	38.4 [38.4, 38.4]
	Drinks only	38.3 [38.3, 38.3]
	Drinks and amusement	42.9 [42.9, 42.9]
	Drinks and music	40.5 [40.5, 40.5]

Table 8: Estimated sunk cost of entry. 95% confidence intervals in parentheses.

significantly reduce the variety offered to the consumer.

Table 7 includes confidence intervals for each of these estimates. I calculate confidence intervals using a Monte Carlo process. Specifically, I re-draw five thousand parameter vectors from an normal distribution with the estimated parameters as its mean and the estimated variance matrix as its variance. Then, I re-calculate the median entry costs and exit payoffs under each of these re-drawn parameter vectors. I use the resulting distribution of median entry costs and exit payoffs to form confidence intervals.

As noted previously, the payoff upon exit is substantially lower than the sunk cost of entry. However, the parameter estimates suggest a deterministic component of the exit payoff that is small compared to the stochastic component. Therefore, depending on the realization of the stochastic components, venues facing an opportunity to exit face a range of possible realizations of the exit payoff shock.

Abbring and Campbell (2005) find that the value of a nightlife venue in its first year of operation lies mostly in its potential to exit the market; their structural estimates indicate that the payoff from exit is 124% the continuation value of a firm in its first year of operation.

extensive regulatory process which includes licensing and application fees as well as extensive documentation requirements. Fullbright (n.d.) gives a "low-end estimate" of the cost to start a nightclub of $239,250 and a "high-end estimate" of $837,100. Samadi (2012) suggests the cost of opening a venue ranges from $100,000 to $200,000 to $1 million or more, depending on venue size.

Conversely, my estimates suggest that for a "Drinks only" venue that has just entered the market that has just entered the market, the payoff from exit is 35.5% of the continuation value. While still substantial, this result is much lower than the Abbring and Campbell (2005) estimate. The discrepancy may arise from differences in the attribution of fixed costs. While my model includes an initial sunk cost immediately upon entry and a constant fixed cost thereafter, Abbring and Campbell (2005) account for the cost of entry by allowing fixed cost to vary over time and therefore their model yields a lower continuation value early in the firm's operation as the cost of entry is effectively being subtracted from the flow of profit.

4.2 Goodness of fit

In interpreting these results, it is worth examining how well the model's predictions match observed data. As a check on the model's goodness of fit, I use the estimated parameter values to solve the via value function iteration then compare the wait times between transitions (i.e., venue entry or exit) as predicted by the model to the wait times between transitions as actually observed. This measure indicates reasonably close fit; the correlation between observed and predicted wait times is 0.322. Averaging over observations with the same number of incumbents n_m (but different demographics d_m and regulation r_m) gives a correlation of 0.479. Both of these values are highly statistically significant. Figure 6 plots the observed and predicted wait times between state transitions. The observed and predicted values are clearly positively correlated. The model has some tendency to overestimate the frequency of state transitions; most of the time, this occurs because the model predicts more rapid exit of venues than actually observed.

4.3 Counterfactual scenarios

The estimation results above allow for the evaluation of counterfactual scenarios in both the static and dynamic context. I use it to evaluate the impact on consumer welfare and profits of the marginal venue entry in each neighbourhood as well as the dynamic impacts of changes to barriers to entry.

4.3.1 Static counterfactuals

Figure 7 shows the median changes in consumer welfare across all observations under scenarios where each neighbourhood gains a single venue of a given type ℓ[24]. These results account for changes to changes of consumers who choose to go out as well as those who choose to consume their reservation utility. Because the reservation utility V^* is uniformly distributed on the unit interval and consumers will only consume the reservation utility if it is greater than the utility V of going out, the expected overall consumer welfare for $V < 1$ is $\Pr(V^* \leq V) V + Pr(V^* > V) \mathbb{E}[V^* \mid V^* > V] = \frac{1}{2} + \frac{1}{2}V^2$. (If $V > 1$ all consumers choose to go out and the welfare is V.)

As shown, the South Side of Chicago is particularly underserved at current levels and welfare would increase substantially with additional venues of any type. Utility gains are particularly strong for "Amusement only" venues in the South Side and for "Drinks only" venues throughout the city. The median welfare gain from a new "Drinks only" venue is on the order of 13.5% while the median welfare gain for the other types is below 3%.

To interpret these welfare gains, it is helpful to express the welfare changes in terms of the magnitude of venue price reduction that would give consumers the same increase to utility. Since both prices and consumer budget w are normalized by the entry cost, this is equivalent to the increase in w that would give the same increase in utility. As shown in Equation 3, the utility $V(p)$ for consumers who choose to go out and consume nightlife services is proportional to w. (As shown in Equation 6, venue prices are independent of w.) Therefore, the compensating variation in w (i.e., the change in w that would give consumers the same welfare gain as a new venue) is identical to the proportional change in welfare shown in Figure 7.

Table 9 summarizes the percentage changes in median profits for venues of type ℓ across all observations when a venue of type ℓ' enters the market. I calculate the confidence intervals using the same Monte Carlo method as in Table 8. As shown, the parameter estimates suggest that on the median profits generally decline with the entry of an additional venue. However, the estimated changes to profits are close to zero. In the median observation, a new entrant leads to enough new consumers to almost entirely offset the additional competition for incumbent venues.

Table 10 gives a related result for the same counterfactual. It summarizes the share of

[24] This analysis of consumer welfare omits any potential negative externalities of nightlife venues. Accordingly, these results should not be interpreted as the equilibrium welfare change for Chicago residents as a result of nightlife activity, but rather the utility of potential nightlife consumers.

	Amusement only	Drinks only	Drinks and amusement	Drinks and music
Amusement only	-22.4	-4.1	-46.6	-2.5
	[-22.4,-22.4]	[-4.1,-4.1]	[-46.8,-43.9]	[-2.3,-2.3]
Drinks only	-2.3	-2.7	-5.2	-2.2
	[-2.4,-2.3]	[-2.7,-2.7]	[-5.2,-5.1]	[-2.2,-2.2]
Drinks and amusement	-0.2	-0.5	-72.7	-0.1
	[-0.2,-0.2]	[-0.5,-0.5]	[-72.3,-71.8]	[-0.1,-0.1]
Drinks and music	-0.8	-1.5	-11.8	-20.3
	[-0.8,-0.8]	[-1.5,-1.5]	[-11.8,-11.7]	[-20.3,-20.3]

Table 9: Effect on profits of one more venue of each type. The column variable is the type of the entrant while the row variable is the type whose change in profit is shown. All values are expressed in percentage changes from the baseline results. 95% confidence intervals in parentheses.

Amusement only	36.3	13.2	6.7	14.1
	[36.3,36.3]	[13.2,13.2]	[6.7,6.7]	[14.1,14.1]
Drinks only	13.3	13.2	17.8	8.4
	[13.3,13.3]	[13.2,13.2]	[17.8,17.8]	[8.4,8.6]
Drinks and amusement	0.0	1.1	32.2	12.4
	[0.0,0.0]	[1.1,1.1]	[32.2,32.2]	[12.4,12.4]
Drinks and music	0.0	1.1	13.3	25.3
	[0.00.0,]	[1.1,1.1]	[13.3,13.3]	[25.3,25.3]

Table 10: Proportion of observations where a new entry would increase the profit of incumbent venues. The column variable is the type of the entrant while the row variable is the type whose change in profit is shown. All values are expressed in percentage of observations. 95% confidence intervals in parentheses.

observations in which one (counterfactual) entrant would increase profits for incumbents. As shown, in a significant share of observations an additional venue would lead to enough additional demand to increase incumbent profit. Venues of the "Amusement only" and "Drinks and amusement" types have a high incidence of spillover to venues within the same type, while venues of the "Drinks only" type have a high incidence of spillover to venues of different types.

4.3.2 Dynamic counterfactuals

Next, I use the model to evaluate dynamic counterfactual scenarios. Throughout, I assume the stochastic form of the sunk cost shock and the exit payoff shock remain unchanged. Under each counterfactual, I re-solve the model using value function iteration under the counterfactual. Note that these counterfactual predictions also represent a Markov-Nash equilibrium; in the counterfactuals, agents have consistent beliefs regarding each others' actions as a function of the current state.

First, consider a dynamic counterfactual where the deterministic component of the sunk cost of entry is exogenously lowered by 25% for all potential entrants in all neighbourhoods — a change comparable to one standard deviation of the within-sample variation in entry cost. Figure 8 shows the change in predicted entry rate, expressed in terms of venues per year. As shown, the effects of lower barriers to entry are substantial. In some neighbourhoods, this would increase the rate of entry (relative to the final period of the model) by five "Drinks only" venues per year and over 0.7 "Amusement only" and "Drinks and amusement" venues per year. The effects are largest on the South Side (which has a lower density of venues venues) and smallest in Central Chicago (which has a higher density of venues). This result suggests that policy changes to lower the entry costs could potentially lead to a drastic increase in the number of venues in neighbourhoods with relatively few venues.

Next, consider a laissez-faire counterfactual where all local regulation (i.e., dry precincts and moratoria) are removed. Under this counterfactual, venues still face barriers to entry (due to startup costs and citywide regulation) but the cost is substantially lower. As shown in Figures 4a and 4b, the impact of this counterfactual is largest in a few particularly heavily-regulated neighbourhoods. Figure 9 shows the change in entry rate under this scenario. As shown, the effect under the laissez-faire counterfactual is generally smaller than the effect under the counterfactual with across-the-board entry barrier reduction. To some extent, this may be due to the most heavily-regulated neighbourhoods representing low profit to potential entrants. At any rate, this counterfactual provides evidence that the high barriers to entry are not primarily driven by local liquor license restrictions (as opposed to municipal regulation or non-regulatory startup costs).

5 Robustness

To ensure that the model above is well-specified (and, in particular, to ensure that the effects attributed to η and ρ_ℓ actually represent the effects on venue profit from consumer preferences for variety) I re-estimate the model under different specifications.

5.1 Cluster neighbourhoods

The results presented above use the community area boundaries developed by the University of Chicago's Local Community Research Committee to define neighbourhoods. As discussed previously, these do not seem to be an unreasonable unit for discretization. Community areas have a reasonable size for nightlife consumers to travel within them, they are roughly convex, and in many cases they correspond with residents' contemporary definition of neighbourhoods.

To ensure that these neighbourhoods correspond reasonably with nightlife consumers' actual choice sets, I re-estimate the model using a definition of neighbourhoods based on the clustering algorithm introduced in Rozenfeld et al. (2011). I fix a spatial distance d, and use the algorithm to define a neighbourhood as the maximal spatial region in which no venue is at a distance greater than d from any other venue[25]. Let V denote the set of all venues in the sample - then, the algorithm proceeds as follows:

- Choose a venue v_o that is not yet assigned to a neighbourhood. Draw a circle of radius d around venue v_o. Assign the set of venues $\{v' \in V \mid |v' - v_o| \leq d\}$ (that is the set of venues in the circle of radius d around the venue v_o) to the same neighbourhood as v_o.

- For each newly-assigned venue v' from Step 1, draw a new circle of radius d and assign all not-yet-assigned venues to the same neighbourhood.

- Repeat Step 2 until the newly-drawn circles of radius d no longer incorporate any new venues. The union of all circles from Steps 1 and 2 define a neighbourhood.

- Repeat Steps 1 through 3 starting with a new unassigned venue to define new neighbourhoods until no unassigned venues remain.

At the end of this process, every venue is assigned to a neighbourhood. The resulting cluster neighbourhoods are independent of the starting point; each radius d defines a unique set of neighbourhoods. Within each of these neighbourhoods, no venue is at any distance greater than d from at least one other venue. For suitable values of d, this defines a neighbourhood as including the maximal set of venues that consumers could access in a single night. I choose d to give neighbourhoods of a comparable size to the community areas described above — specifically, I consider the case $d = 500$m. Figure 10 shows the resulting cluster neighbourhoods. I re-estimate the model using these new neighbourhoods.

[25] To ensure time-invariant neighbourhood boundaries, I include all sites at which a venue is ever observed in the sample.

Elasticity	Symbol	$d = 250$m	$d = 500$m	$d = 750$m
Between sectors	η	2.02	2.07	2.04
		(2.4×10^{-4})	(2.4×10^{-4})	(2.9×10^{-3})
Amusement only	ρ_1	5.68	6.72	4.32
		(1.7×10^{-4})	(0.07)	(0.17)
Drinks only	ρ_2	2.05	2.07	2.08
		(1.8×10^{-5})	(8.8×10^{-5})	(1.3×10^{-3})
Drinks and amusement	ρ_3	3.82	5.73	5.44
		(5.5×10^{-4})	(0.02)	(0.21)
Drinks and music	ρ_4	5.88	8.35	6.52
		(0.15)	(2.26)	(3.28)

Table 11: Maximum likelihood estimation results for the CES parameters η and ρ_ℓ with clustered neighbourhoods of varying sizes. Table 5 shows the corresponding baseline elasticity values. Standard errors in parentheses.

Table 11 shows the elasticity estimates under varying cluster sizes. As shown, the elasticity results under cluster neighbourhoods are very similar to the results generated using the community areas in Table 5. In particular, the elasticity between sectors η is again slightly greater than 2 and the within-sector elasticities have similar values and the same ranking order. (Moreover, the standard errors are generally much smaller.) This provides supporting evidence that the results presented above are not an artifact of the community area neighbourhood boundaries.

The estimation results suggest that consumer preference for variety is stronger with smaller clusters in the "Drinks and amusement" and "Drinks and music" categories. Insofar as consumers are more averse to travelling long distance between venues on a single night out, this may indicate that consumer preference in these categories arises from bar-hopping in the course of a single night. However, the other two sectors do not display a similar pattern.

5.2 Separate entry and exit rates

In the model presented above, entrants' actions are estimated partially based on the action of the pool of entrants and incumbents' actions are estimated partially based on the action of the pool of incumbents. Accordingly, there is an aspect to the estimation that resembles reflection; for example, in a neighbourhood of many successful incumbents with a low exit rate, I observe successful venues and attribute their success to positive agglomeration effects[26]. This may cause concern that the parameter σ is not actually capturing the benefits of other nearby venues but some other factor in venues' decisions —- for example, "animal spirits" among entrants that cause them to enter irrationally based on the rate of each others' entry. Therefore, as an additional check, I address this by estimating the structural parameter from the entry and exit decision separately.

Specifically, I estimate the potential entrants' entry decisions using the structural value functions as a response to the nonparametric forms of the exit rates and with a separate likelihood maximization estimate the incumbents' exit decisions using the structural value functions as a response to the nonparametric forms of the entry rates. That is, I estimate the parameter vector θ from Equation 15 using first-stage nonparametric estimates $\hat{h}_x(s)$ from Equation 12 for exit rates but structural predictions (which depend on the parameter vector) for entry rates. Then, I repeat this process with first-stage nonparametric estimates $\hat{h}_e(s)$ for the entry rates and structural productions for the exit rates. While these estimations provide the second-stage likelihood estimation with fewer observations, it ensures that the structural parameters are estimated from one group of agents' actions in response to another group's actions.

Table 12 shows the elasticity results under these restricted estimation schemes. As show, estimating the structural parameters by matching only the exit rate gives very similar results to the baseline estimates in Table 5. However, matching using only the entry rates gives much higher values for the elasticities. The cause of this discrepancy is unclear.

5.3 Profit from Starbucks

While the estimation results presented above control for observable characteristics including demographics, transit access, and the nature of the built environment, they may still be biased by unobservable heterogeneity. For example, if some other attribute uncorrelated with these observable characteristics positively impacts venue profits and more venues enter in neighbourhoods with this attribute, then the estimation will erroneously attribute this increased entry rate to consumer preference for variety. One particularly salient source of potential unobservable heterogeneity is whether the neighbourhood is a pleasant area for consumers – for example, due to ease of pedestrian movement, appealing-looking buildings,

[26] Note that due to the structural nature of this model this is not reflection in the strictest sense of the term. However, as a check on the model's ability to identify the profit function, it is useful to check whether this issue influences the results.

Elasticity	Symbol	From entry rate	From exit rate
Between sectors	η	6.72	2.03
		(1.8×10^{-5})	(3.1×10^{-4})
Amusement only	ρ_1	45.81	4.79
		(9.1×10^{-4})	(1.0×10^{-3})
Drinks only	ρ_2	8.25	2.25
		(1.1×10^{-5})	(2.5×10^{-4})
Drinks and amusement	ρ_3	6.71	3.30
		(1.4×10^{-3})	(0.01)
Drinks and music	ρ_4	9.93	7.31
		(0.02)	(0.08)

Table 12: Maximum likelihood estimation results for the CES parameters η and ρ_ℓ under estimation matching only the entry rate and only the exit rate. Table 5 shows the corresponding baseline elasticity values. Standard errors in parentheses.

a positive reputation, or other attributes. Researchers in the urban planning literature refer to these aspects of a commercial neighbourhood's aesthetic quality and ease of access as the "streetscape"[27].

To investigate the possibility that the estimation results above reflect streetscape quality rather than the presence of many nightlife venues, I re-estimate the model using the venues' response to the local density of Starbucks rather than the local density of other venues. Insofar as Starbucks locations tend to cluster near areas with high consumer foot traffic, Starbucks outlets seem like a reasonable proxy for unobservable streetscape attributes. The same data set that contains the liquor licenses also contains Starbucks locations, including spatial coordinates and entry and exit dates.

Specifically, I re-estimate the model using a profit function of the following form:

$$\pi_{m\ell i} = A_\ell + B_\ell \zeta_m + C_\ell \zeta_m^2 + D d_m \tag{18}$$

In Equation 18, ζ_m is the number of Starbucks locations in neighbourhood m, d_m is the vector of demographic attributes in neighbourhood m, and A_ℓ, B_ℓ, C_ℓ, and D are parameters to be estimated. Under this model, venues form their forward-looking expectations based on entry and exit of Starbucks locations, which I estimate nonparameterically. I allow the sunk cost of entry to vary with neighbourhood-level regulation as above. If the profit is constant

[27] Campo and Ryan (2008) describe the importance of the streetscape for nightlife venues. Darchen (2013*b*) and Zimmerman (2008) discuss policymakers' attempts to promote nightlife by upgrades and renovations to the streetscape.

	Amusement only	Drinks only	Drinks and amusement	Drinks and music
A	-9.16×10^{-5}	3.37×10^{-3}	4.15×10^{-4}	1.42×10^{-3}
	(3.29×10^{-3})	(5.68×10^{-2})	(4.78×10^{-2})	(2.03×10^{-2})
B	-8.70×10^{-3}	6.04×10^{-3}	1.02×10^{-2}	-4.72×10^{-3}
	(3.56×10^{-4})	(1.21×10^{-3})	(3.89×10^{-3})	(7.80×10^{-4})
C	6.17×10^{-3}	8.85×10^{-4}	-9.18×10^{-3}	2.65×10^{-3}
	(2.11×10^{-5})	(3.65×10^{-5})	(3.20×10^{-4})	(3.95×10^{-5})

Table 13: Maximum likelihood estimation results for the parameters A, B, and C from the profit function specification in Equation 18. Standard errors in parentheses.

with respect to the number of Starbucks, this provides supporting evidence that ρ_ℓ and η are actually measuring consumer preference for variety of venues rather than some other local condition.

Table 13 shows the resulting parameter values for the relationship between Starbucks density and profit. As shown, the estimations results indicate no systematic role for Starbucks in the profit function. Conditional on neighbourhood attributes, the signs of the coefficients are neither systematically positive nor negative. These results do not support the hypothesis that the preference for variety implied by the results in Table 5 is actually driven by unobservable local-level attributes of local commercial districts.

6 Conclusion

Economic literature and urban policymakers have recognized that consumer amenities are an important determinant of migration and quality of life. While consumers appear to value nightlife as a particularly important amenity, it has received less attention in the economic literature, possibly due to a scarcity of detailed data. In this paper, I estimate a dynamic structural model which identifies the profit function and consumer preferences for variety from observed venue entry and exit decisions. I use the estimation results to examine counterfactual scenarios of industry dynamics.

The results of the estimation suggest that consumers place a high value on variety in nightlife venues. In particular, consumers have less of a strong preference for access to variety in venues with music and dance (i.e., nightclubs) while they are very sensitive to variety in venues which serve drinks but do not offer additional amenities (i.e., bars). The preference for variety in the latter category is comparable to the preference for variety in highly-variety specific goods in the international trade literature. The CES parameter values for public places of amusement with and without alcohol sales are comparable to the results in the literature for preference for variety across restaurants.

The results also indicate that nightlife venues face very high barriers to entry. This limits the available variety of venues and lowers consumer welfare. Initially this would seem to suggest that the optimal policy response would include lower barriers to entry. However, as this study does not account for the negative impacts of nightlife venues, the optimal response is less straightforward. In terms of policy applications, this study does estimate the value to nightlife consumers as well as the impact of new venues on incumbents. In particular, if the new entrant is a nightclub then existing venues experience a relatively small decline in their own profits as the draw of additional customers largely compensates for the increased competition.

These results appear to be fairly robust. Changes to specification do not appear to affect the estimates of consumer preference for variety. As well, as discussed above, the structure of the Chicago nightlife industry and additional estimation results rule out plausible alternate explanations for the observed results.

This study also indicates directions for further research in understanding the valuation and development of consumption amenities in cities. In particular, a similar model of consumer preference for high-variety amenities could be used to investigate other urban consumption amenities with limited data — for example, musical performances or other cultural events. With a more detailed data set, one could infer additional details of consumer preference for variety, particularly in terms of consumers preferences across differing income levels or demographic groups.

The theoretical and empirical results in this study could be extended by allowing greater flexibility in venue location choices. In the current model, entrants can only choose to enter a specific neighbourhood rather than a specific location within the neighbourhood. This could theoretically be relaxed to allow potential entrants to choose a neighbourhood or even to allow potential entrants to choose any location. As mentioned previously, greater flexibility would massively increase the dimensionality of the state space and this estimation would require a much larger data set. However, this extension would allow for a more comprehensive understanding of the agglomerative forces arising from consumer preferences for variety in the nightlife industry.

A Proof of Proposition 1

This appendix provides a proof for Proposition 1, which guarantees the existence of a unique set of equilibrium prices for the static model outlined above. It builds on the proof provided in Kucheryavyy (2012). I extend this result to account for venues' response to consumers' reservation utility.

This proof only applies for the case where $n_\ell > 0$ for all venue types ℓ. In $n_\ell = 0$ for some type, then no well-defined equilibrium price exists. However, upon removing the type ℓ with $n_\ell = 0$ from consideration, the proof does hold for the remaining types.

For clarity, I focus on the case where $N < \bar{N}$ — that is, where $V(p) < 1$ and therefore some consumers are opting not to go out and instead to consume their reservation utility. The proof for the case where $N \geq \bar{N}$ follows the same rationale but with less complexity.

First, I prove the uniqueness of the vector of prices. Equation 6 gives prices $p_{\ell i}$ as a function of the market shares S_ℓ:

$$p_{\ell i} = \left(1 + \frac{n_\ell}{n_\ell\left(\rho_\ell - 1\right) - \left(\rho_\ell - \left[1 + S_\ell^{\frac{\eta}{\eta-1}} \sum_{\ell'} \left(S_{\ell'}^{\frac{\eta}{\eta-1}}\right)^{-1}\right]\eta\right) - 2\left(\eta - 1\right) S_\ell} \right) c_\ell \tag{19}$$

Note that Equation 2 suggests that the share of consumption to sector ℓ S_ℓ can be written in terms of the price index P_ℓ as follows:

$$S_\ell = \frac{P_\ell^{1-\eta}}{\sum_{\ell'} P_{\ell'}^{1-\eta}} \tag{20}$$

For symmetric venues, $P_\ell = n^{\frac{1}{1-\rho_\ell}} p_{\ell i}$. Substituting $p_{\ell i}$ gives the following fixed-point equation for S_ℓ:

$$S_\ell = \frac{n_\ell^{\frac{1-\eta}{1-\rho_\ell}} \left(1 + \frac{n_\ell}{n_\ell(\rho_\ell - 1) - \left(\rho_\ell - \left[1 + S_\ell^{\frac{\eta}{\eta-1}} \sum_{\ell'} \left(S_{\ell'}^{\frac{\eta}{\eta-1}}\right)^{-1}\right]\eta\right) - 2(\eta-1)S_\ell} \right)^{1-\eta} c_\ell^{1-\eta}}{\sum_{\ell'} n_{\ell'}^{\frac{1-\eta}{1-\rho_{\ell'}}} \left(1 + \frac{n_{\ell'}}{n_{\ell'}(\rho_{\ell'} - 1) - \left(\rho_{\ell'} - \left[1 + S_{\ell'}^{\frac{\eta}{\eta-1}} \sum_{\ell''} \left(S_{\ell''}^{\frac{\eta}{\eta-1}}\right)^{-1}\right]\eta\right) - 2(\eta-1)S_{\ell'}} \right)^{1-\eta} c_{\ell'}^{1-\eta}} \tag{21}$$

This defines a system of L equations for the shares S_ℓ which map the hypercube $[0,1]^L$

into itself[28]. As this is a continuous mapping of a closed set into itself, Brouwer's fixed point theorem applies. Therefore, an equilibrium S_ℓ must exist.

Next, note that this equilibrium must be unique. To see this, note that the left-hand side of Equation 21 is strictly increasing and continuous in S_ℓ while the right-hand side is strictly decreasing and continuous. Therefore, they must intersect at most once. Because Brouwer's fixed point theorem guarantees that they intersect at least once, it must be that they intersect exactly once. Therefore, there exists a unique equilibrium set of shares S_ℓ. Substituting into 2 gives a corresponding unique equilibrium set of prices.

This completes the proof. While the exposition has focused on the case where $V(p) < 1$, a directly analogous proof holds for $V(p) \geq 1$. In this case, the expression for the fixed-point equation for S_ℓ (the equivalent of Equation 21) is as follows:

$$S_\ell = \frac{n_\ell^{\frac{1-\eta}{1-\rho_\ell}} \left(1 + \frac{n_\ell}{n_\ell(\rho_\ell - 1) - (\rho_\ell - \eta) - (\eta - 1)S_\ell}\right)^{1-\eta} c_\ell^{1-\eta}}{\sum_{\ell'} n_{\ell'}^{\frac{1-\eta}{1-\rho_{\ell'}}} \left(1 + \frac{n_{\ell'}}{n_{\ell'}(\rho_{\ell'} - 1) - (\rho_{\ell'} - \eta) - (\eta - 1)S_{\ell'}}\right)^{1-\eta} c_{\ell'}^{1-\eta}} \tag{22}$$

It remains to show that either the case $V(p) < 1$ or the case $V(p) \geq 1$ yields consistent results. That is, it remains to show that either when venues follow the pricing strategy specified by the first option in Equation 6 the value to consumers of going out is less than 1 or when venues follow the pricing strategy specified by the second option in Equation 6 the value to consumers of going out is greater than 1. That is, let p^{non} be the vector of venue prices given by the first-order condition for the case $V(p) < 1$ and p^{max} be the vector of venue prices given by the first-order condition for the case $V(p) \geq 1$. Then, it remains to show that in all situations either $V(p^{non}) < 1$ or $V(p^{max}) \geq 1$.

I prove this by showing $p^{max} \leq p^{non}$. Then, according to Equation 3, $V(p^{non}) \leq V(p^{max})$. From here, the desired consistency result follows immediately. To show this, rearrange Equation 6 as follows:

$$\left(\frac{p_{\ell i}^{non}}{c_\ell} - 1\right)^{-1} = \left(\frac{p_{\ell i}^{max}}{c_\ell} - 1\right)^{-1} + \eta S_\ell^{\frac{\eta}{\eta-1}} \left(\sum_{\ell'} S_{\ell'}^{\frac{\eta}{\eta-1}}\right)^{-1} - (\eta - 1)S_\ell \tag{23}$$

From here, it is sufficient to show $\eta S_\ell^{\frac{\eta}{\eta-1}} \left(\sum_{\ell'} S_{\ell'}^{\frac{\eta}{\eta-1}}\right)^{-1} - (\eta - 1)S_\ell \geq 0$ for all possible S_ℓ.

[28]Strictly speaking, Equation 21 defines a mapping on the set $[0,1]^L \setminus 0$ as the term $S_\ell^{\frac{\eta}{\eta-1}} \sum_{\ell'} \left(S_{\ell'}^{\frac{\eta}{\eta-1}}\right)^{-1}$ is not defined when all shares S_ℓ are identically zero. However, this singularity is removable; setting this term to one when all shares are zero yields a continuous function.

Note that this is guaranteed to hold for $S_\ell = 0$ and for $S_\ell = 1$. It remains to show that it holds for the interior critical point. Taking the first-order condition and rearranging yields a minimum when $\eta S_\ell^{\frac{\eta}{\eta-1}} = \sum_{\ell'} S_{\ell'}^{\frac{\eta}{\eta-1}}$. However, at this value of S_ℓ, the necessary condition holds whenever $S_\ell^{-1} > \eta - 1$, which is satisfied whenever $\eta > 2$. Therefore, $p^{max} \leq p^{non}$. This completes the proof.

It is worth discussing the intuition for the requirement $\eta > 2$. In the case $\eta \leq 2$, consumers are very sensitive to variety between venues. In this case, depending on parameter values, it is possible that an individual venue in the $V(p) < 1$ case may lower prices below p^{max} to entice more consumers to come out. In this case, there is no guarantee that either pricing strategy will be consistent with the consumers' indirect utility. However, empirically it does appear that $\eta > 2$.

Note that in some cases multiple equilibria are possible — that is, it is possible for a neighbourhood to be in a state such that setting a price vector p^{non} according to the $V(p) < 1$ case gives $V(p^{non}) < 1$ but also setting a price vector p^{max} according to the $V(p) \geq 1$ case gives $V(p) \geq 1$. When this occurs, I assume that the venues set prices according to p^{non}. Not only would any unilateral deviation to p^{max} result in lower profits, but also as a practical consideration using the p^{non} case whenever it is consistent leads to fewer "jumps" in profit as a function of parameters and therefore more tractable estimation. Numerical simulation suggests that when multiple equilibria arise they are both very close to $V = 1$ with similar prices to each other.

B Proof of Proposition 2

This appendix provides a proof of Proposition 2, which states that with sufficiently many venues the equilibrium prices give $V(p) \geq 1$ — that is, with sufficiently many venues, nightlife is sufficiently vibrant that all consumers choose to go out. To prove this result, I show that with sufficiently many venues the optimal price vector p^{non} based on the optimal pricing strategy for the case $V(p) < 1$ yields $V(p^{non}) > 1$. Since Proposition 1 shows that $V(p^{non}) < V(p^{max})$ (i.e., the optimal pricing strategy when $V(p) < 1$ always gives a lower utility than the optimal pricing strategy when $V(p) \geq 1$), the desired result follows immediately.

First, rewrite the indirect utility from Equation 3 entirely in terms of the venues' prices $p_{\ell i}$:

$$V(p) = w \sum_\ell n_\ell^{\frac{\eta}{\rho_\ell - 1}} p_{\ell i}^{-\eta} \left(\sum_\ell n_\ell^{\frac{\eta-1}{\rho_\ell - 1}} p_{\ell i}^{1-\eta} \right)^{-1} \tag{24}$$

From here, it remains to show that for all $\ell \in 1, 2, \ldots, L$, $n_\ell^{\frac{\eta}{\rho_\ell - 1}} p_{\ell i}^{-\eta}$ grows faster in n_ℓ than $n_\ell^{\frac{\eta-1}{\rho_\ell-1}} p_{\ell i}^{1-\eta}$ when $p = p^{non}$. This will provide the necessary result, since it indicates that the value of going out under the $V(p) < 1$ pricing strategy increases indefinitely with n_ℓ.

Note that in Equation 6 the price for the case $V(p) < 1$ (expressed in big-O notation in n_ℓ) is $O(1)$. Specifically, as n_ℓ increases, the optimal price for the case $V(p) < 1$ approaches the constant markup price $p_{\ell i} = \frac{\rho_\ell + 1}{\rho_\ell} c_\ell$. Accordingly, $n_\ell^{\frac{\eta}{\rho_\ell - 1}} p_{\ell i}^{-\eta}$ is $O\left(n_\ell^{\frac{\eta}{\rho_\ell-1}}\right)$ while $n_\ell^{\frac{\eta-1}{\rho_\ell-1}} p_{\ell i}^{1-\eta}$ is $O\left(n_\ell^{\frac{\eta-1}{\rho_\ell-1}}\right)$. As $\frac{\eta}{\rho_\ell - 1} > \frac{\eta-1}{\rho_\ell-1}$, the numerator term grows faster with n_ℓ than the denominator term. Therefore, the overall indirect utility under the $V(p) < 1$ prices must eventually exceed 1 for sufficiently large n_ℓ. This completes the proof.

C Maximum likelihood estimation results

Table 14 shows the full set of parameter results from the maximum likelihood estimation, including not only the parameter values discussed above but also the parameters relating neighbourhood attributes to the profit function. Equations 16 and 17 define how the estimated parameters relate to the model quantities.

Parameter		Symbol	Estimate
Elasticity between sectors		η	2.04
			(1.57×10^{-4})
Elasticity within sector	Amusement only	ρ_1	4.90
			(5.53×10^{-4})
Elasticity within sector	Drinks only	ρ_2	2.15
			(9.79×10^{-5})
Elasticity within sector	Drinks and amusement	ρ_3	3.56
			(3.89×10^{-3})
Elasticity within sector	Drinks and music	ρ_4	7.96
			(1.09×10^{-4})
Marginal cost	Amusement only	c_1	0.127
			(8.87×10^{-5})
Marginal cost	Drinks only	c_2	1.45
			(1.10×10^{-4})
Marginal cost	Drinks and amusement	c_3	3.85
			(9.68×10^{-4})
Marginal cost	Drinks and music	c_4	2.54
			(7.38×10^{-4})

Entry arrival rate	Amusement only	α_1	4.00×10^{-3}
			(6.19×10^{-6})
Entry arrival rate	Drinks only	α_2	9.05×10^{-1}
			(6.33×10^{-4})
Entry arrival rate	Drinks and amusement	α_3	7.18×10^{-1}
			(1.30×10^{-3})
Entry arrival rate	Drinks and music	α_4	1.48×10^{-2}
			(9.16×10^{-4})
Exit arrival rate	Amusement only	λ_1	5.08×10^{-3}
			(1.41×10^{-10})
Exit arrival rate	Drinks only	λ_2	9.03×10^{-3}
			(1.29×10^{-6})
Exit arrival rate	Drinks and amusement	λ_3	2.31×10^{-3}
			(2.06×10^{-6})
Exit arrival rate	Drinks and music	λ_4	2.10×10^{-3}
			(1.89×10^{-8})
Log baseline entry cost	Amusement only	$\theta_{\psi^e \ell 1}$	2.11
			(5.94×10^{-4})
Log baseline entry cost	Drinks only	$\theta_{\psi^e \ell 2}$	2.17
			(2.87×10^{-4})
Log baseline entry cost	Drinks and amusement	$\theta_{\psi^e \ell 3}$	2.11
			(1.89×10^{-4})
Log baseline entry cost	Drinks and music	$\theta_{\psi^e \ell 4}$	1.81
			(6.96×10^{-5})
Log exit payoff	Amusement only	ψ^x_1	-4.01
			(1.17×10^{-4})
Log exit payoff	Drinks only	ψ^x_2	-4.06
			(1.96×10^{-4})
Log exit payoff	Drinks and amusement	ψ^x_3	-2.76
			(2.71×10^{-5})
Log exit payoff	Drinks and music	ψ^x_4	-3.23
			(5.6×10^{-5})
Log entry cost	Dry precincts	$\theta_{\psi^e r 1}$	0.470
			(1.54×10^{-3})
Log entry cost	Moratoria	$\theta_{\psi^e r 2}$	0.106
			(1.88×10^{-4})
Log baseline fixed cost	Amusement only	$\theta_{\kappa \ell 1}$	-4.17
			(1.53×10^{-4})
Log baseline fixed cost	Drinks only	$\theta_{\kappa \ell 2}$	-14.1
			(3.93×10^{-9})
Log baseline fixed cost	Drinks and amusement	$\theta_{\kappa \ell 3}$	-2.39

			(1.36×10^{-3})
Log baseline fixed cost	Drinks and music	$\theta_{\kappa\ell 4}$	-14.1
			(7.18×10^{-9})
Log entrants	Amusement only	ν_1	0.0471
			(4.01×10^{-4})
Log entrants	Drinks only	ν_2	0.0109
			(3.27×10^{-4})
Log entrants	Drinks and amusement	ν_3	0.0185
			(4.96×10^{-4})
Log entrants	Drinks and music	ν_4	0.215
			(5.73×10^{-3})
Log budget		w	2.12×10^{-3}
			(5.23×10^{-7})
Fixed cost parameter	Principal component 1	$\theta_{\kappa d1}$	3.65×10^{-5}
			(3.05×10^{-5})
Fixed cost parameter	Principal component 2	$\theta_{\kappa d2}$	9.36×10^{-3}
			(1.19×10^{-7})
Fixed cost parameter	Principal component 3	$\theta_{\kappa d3}$	-1.44×10^{-4}
			(7.71×10^{-7})
Fixed cost parameter	Principal component 4	$\theta_{\kappa d4}$	1.12×10^{-4}
			(9.93×10^{-6})
Market size	Constant	$\theta_{\bar{N}o}$	4.52
			(2.46×10^{-10})
Market size	Principal component 1	$\theta_{\bar{N}1}$	1.60×10^{-3}
			(6.94×10^{-7})
Market size	Principal component 2	$\theta_{\bar{N}2}$	-2.48×10^{-4}
			(4.48×10^{-6})
Market size	Principal component 3	$\theta_{\bar{N}3}$	1.76×10^{-3}
			(6.29×10^{-7})
Market size	Principal component 4	$\theta_{\bar{N}4}$	-2.25 $\times 10^{-5}$
			(4.94×10^{-5})

Table 14: Maximum likelihood estimation results for all parameters. If the variable name includes "Log", I estimate the logarithm of the corresponding model parameter. Standard errors in parentheses. The notation "—" indicates that the standard error is not precisely estimated via numerical differentiation.

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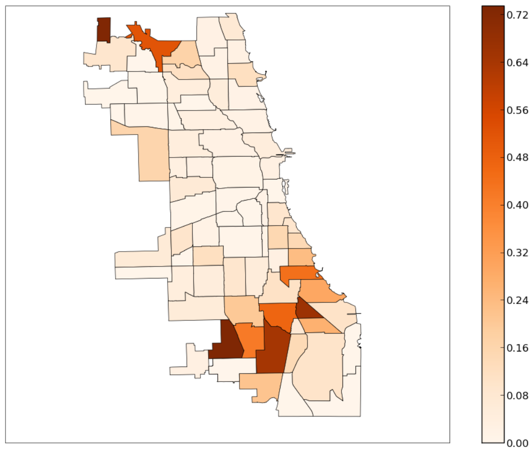
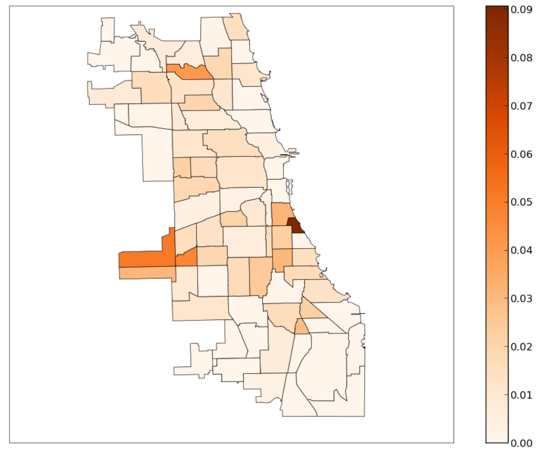
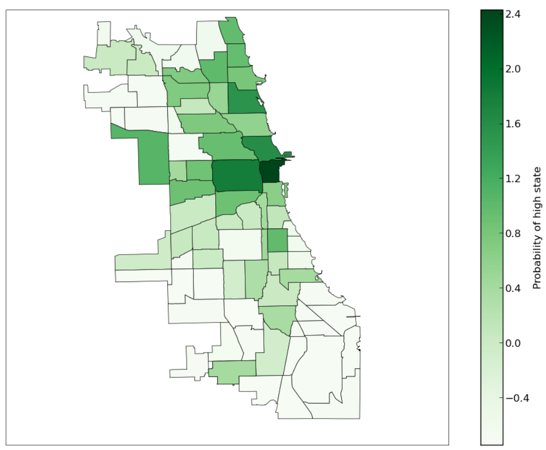


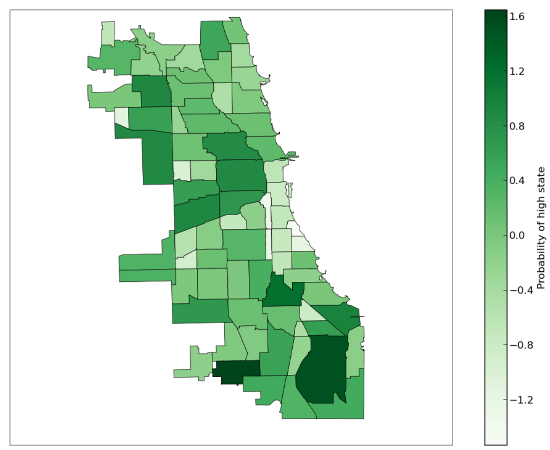
(a) Share of area dry (%)



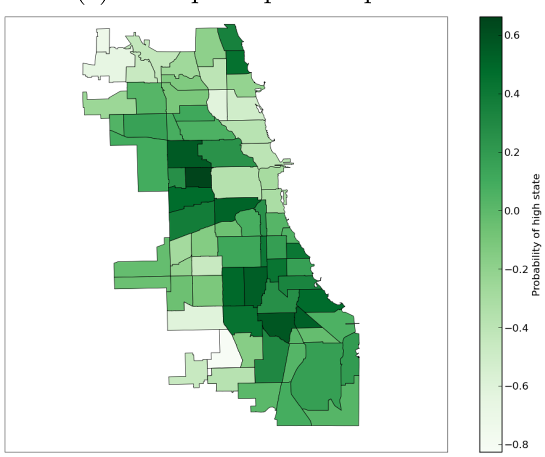
(b) Share of area moratorium (%)



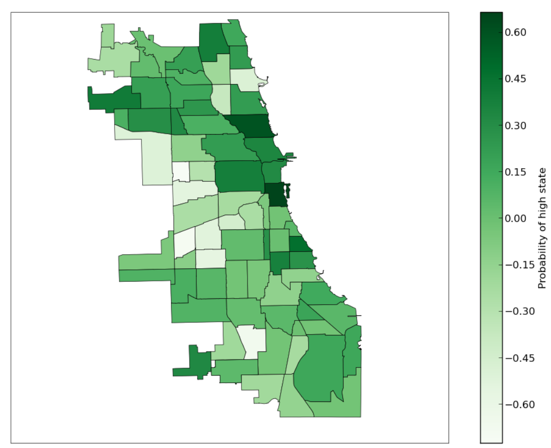
(c) First principal component



(d) Second principal component



(e) Third principal component



(f) Fourth principal component

Figure 4: Neighbourhood attributes.

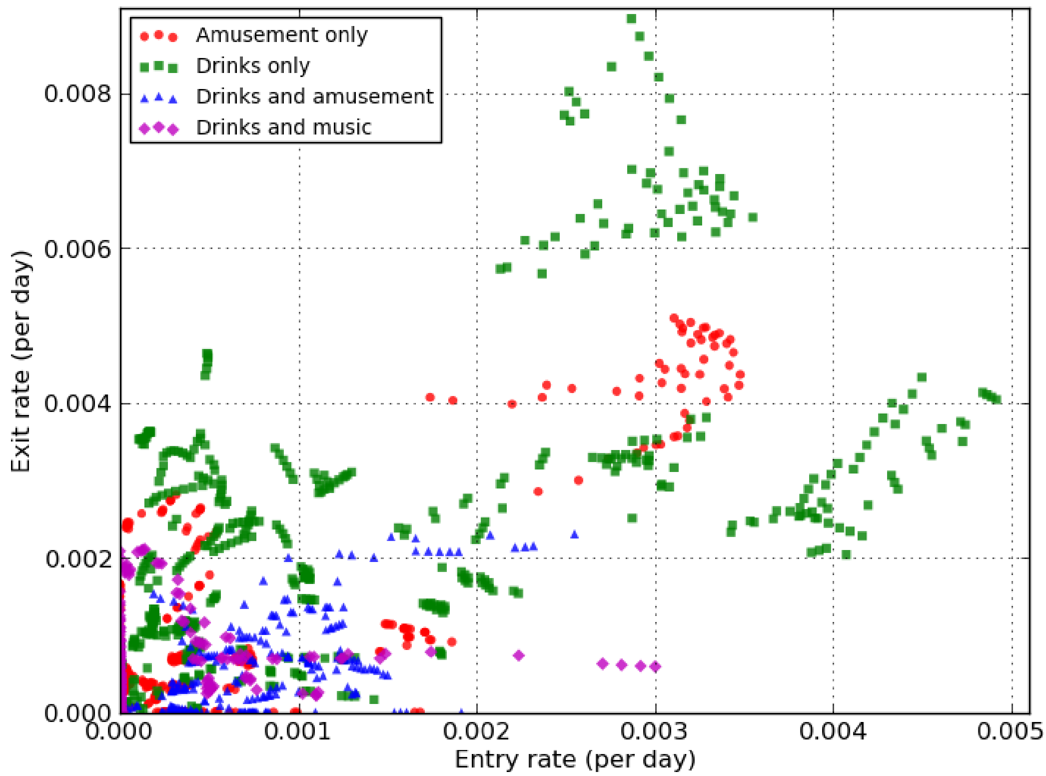


Figure 5: First-stage results for venue entry and exit rates as a function of state. Units are days^{-1} throughout.

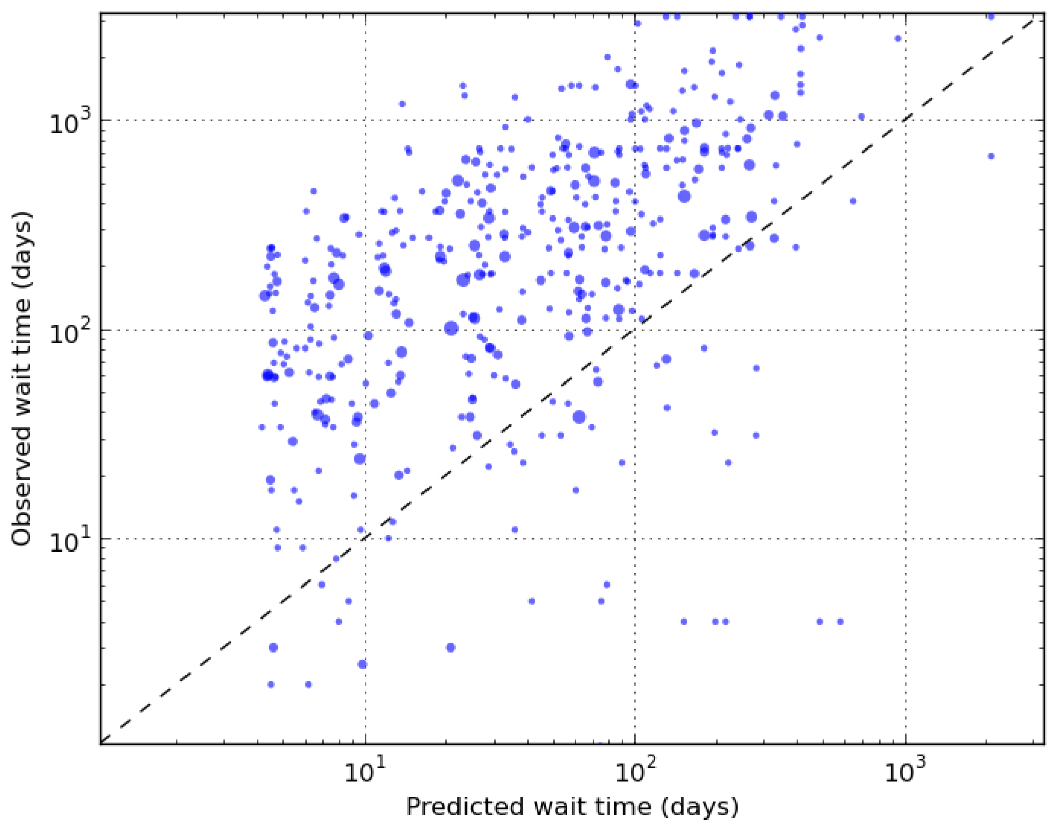
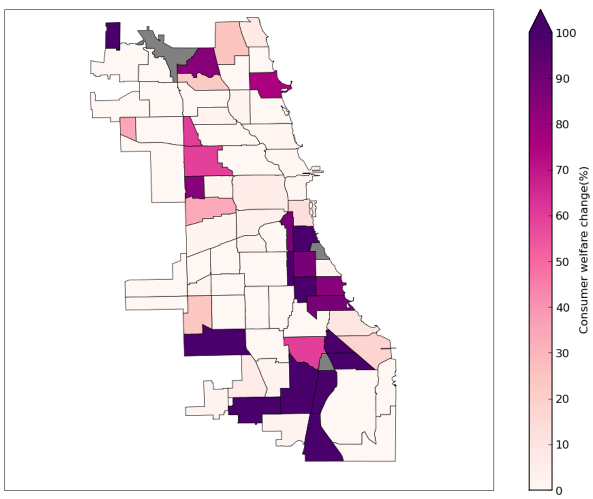
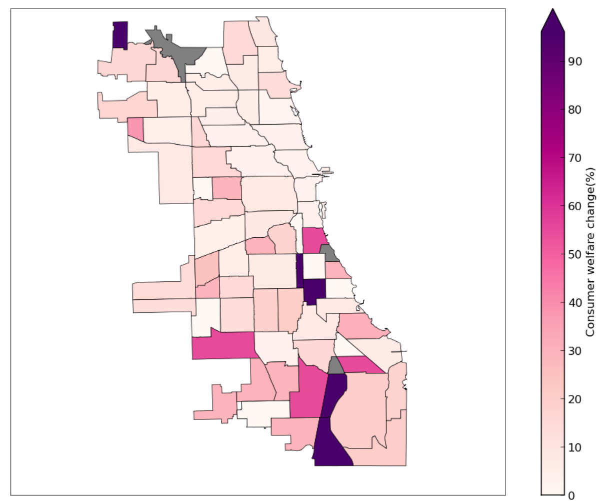


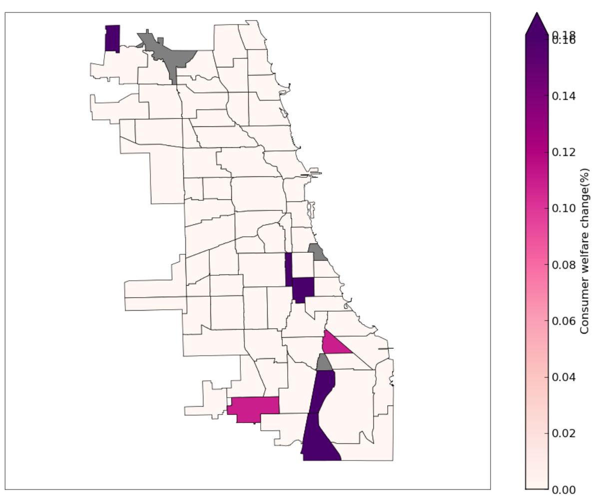
Figure 6: Observed and predicted wait times between state transitions (i.e., venue entry or exit). Each point represents a single (n, d, r) state.



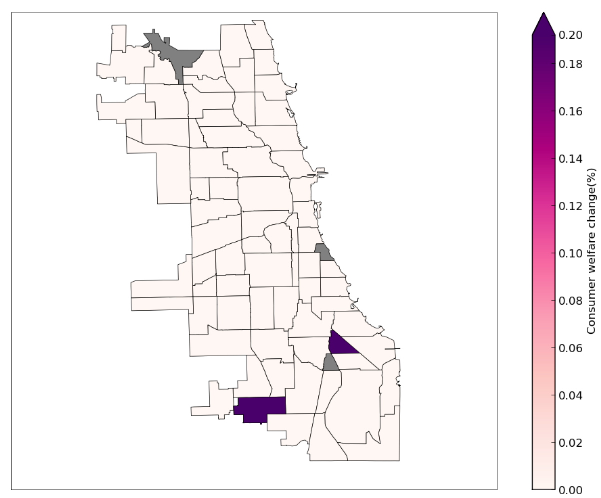
(a) Amusement only



(b) Drinks only

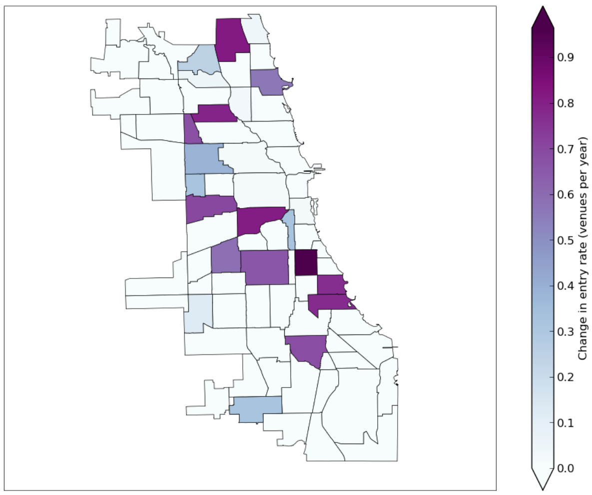


(c) Drinks and amusement

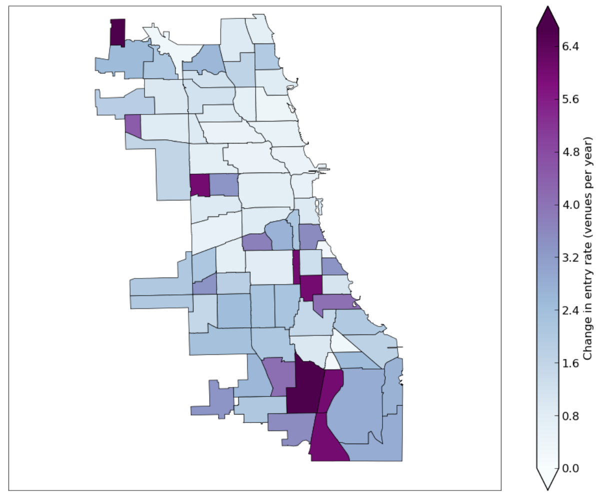


(d) Drinks and music

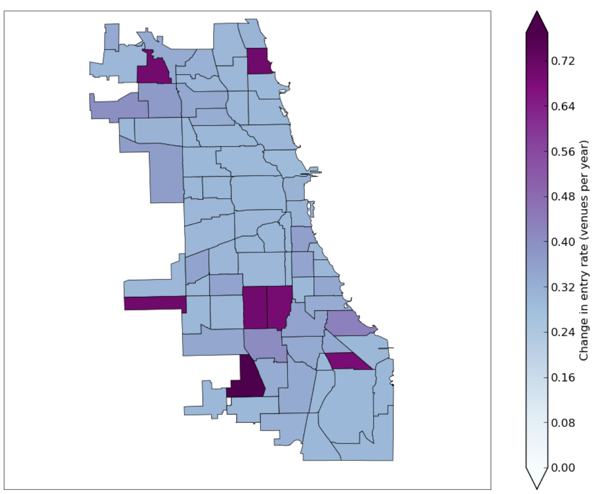
Figure 7: Changes to consumer welfare from one additional venue of each type. All changes expressed as a percentage of the baseline welfare.



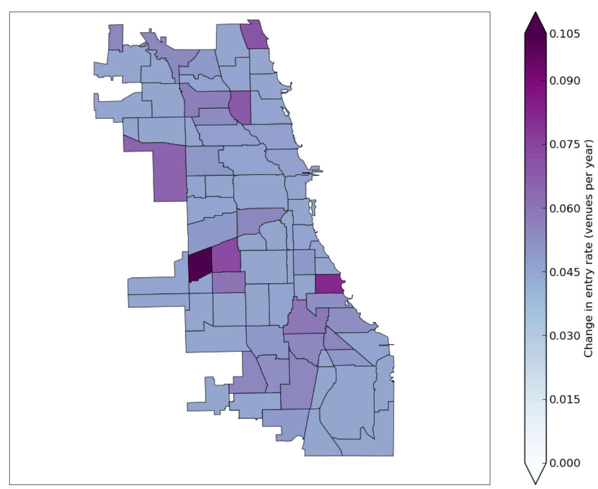
(a) Amusement only



(b) Drinks only

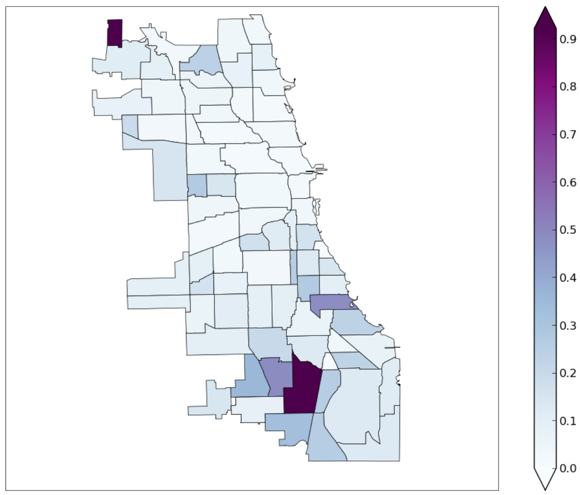


(c) Drinks and amusement

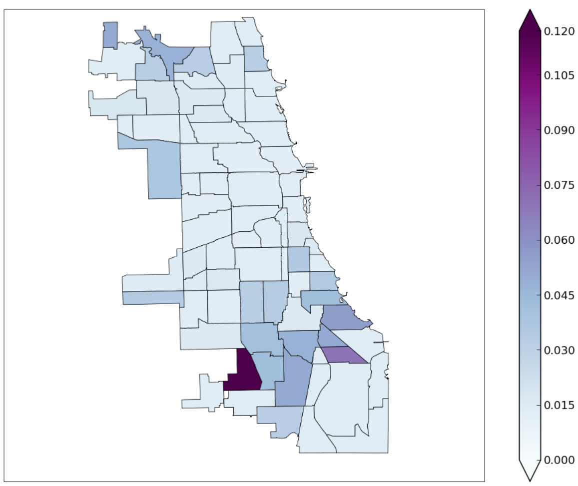


(d) Drinks and music

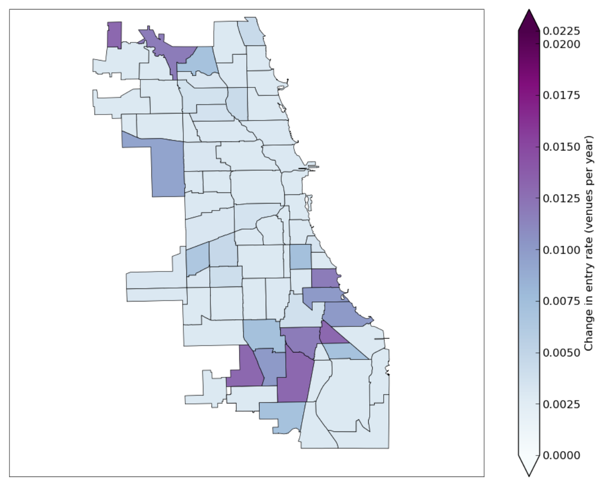
Figure 8: Changes to entry probability from lower entry cost. All changes expressed as the change in the rate of new entrants choosing to enter the market per year.



(a) Drinks only



(b) Drinks and amusement



(c) Drinks and music

Figure 9: Changes to entry probability from laissez-faire local regulation. All changes expressed as the change in the rate of new entrants choosing to enter the market per year. Results for venues in the "Amusement only" category are not shown as venues without liquor licenses do not face local liquor regulation and the indirect effect from other venues' higher entry rate is very small.

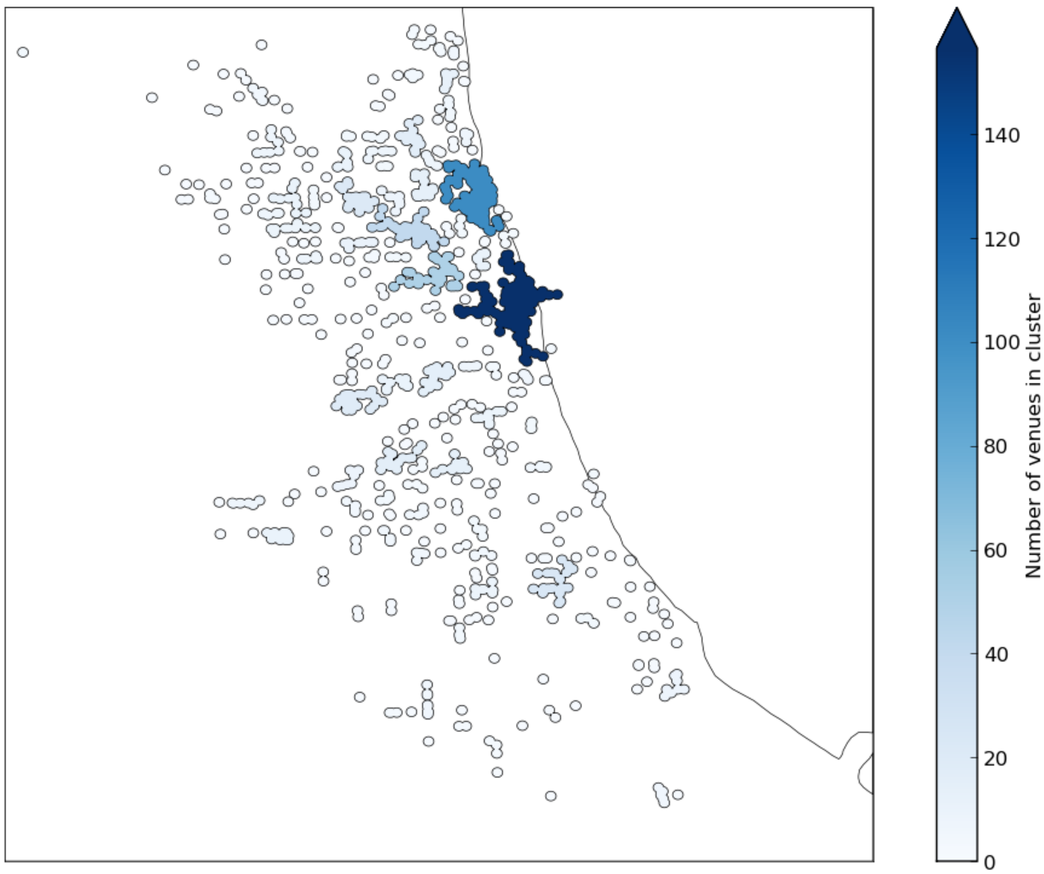


Figure 10: Map of clustered neighbourhoods generated using clustering radius $d = 500$m.