ESSAYS ON REGULATION POLICY, WILDLIFE QUALITY, AND EXCESS DEMAND

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ESSAYS ON REGULATION POLICY, WILDLIFE QUALITY, AND EXCESS DEMAND

Abstract

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The second chapter examines how both domestic and foreign tobacco regulations affect the flow of tobacco trade. I develop a gravity equation incorporating a comprehensive set of domestic and foreign tobacco regulations into a country’s tobacco import demand and estimate their bilateral effects. The results suggest a country’s tobacco imports are significantly affected by their trading partner’s tobacco regulations. There are two important results: spatial regulations reduce tobacco trade regardless of trade direction and marketing regulations in importing countries may actually increase tobacco imports. These results highlight the importance of understand regulations in an increasingly multilateral economy.

The third chapter investigates the effects of varying levels of access and excludability on a common pool resource with intrinsic quality characteristics. I analyze the case of deer hunting on leased properties by hunting clubs and estimate the lease size elasticity of both harvest and antler quality. The results suggest lease size has a small but significant effect. For all clubs with smaller than average hunting leases, a simulated increase to the average size results in approximately a 4.5 percent increase in the average antler quality of deer harvested. Although I
analyze properties leased by hunting clubs, the results are applicable to various other management scenarios.

The fourth chapter develops the relationship between excess demand and purchase options. I illustrate a mechanism allowing firms to smooth sales across periods with uncertain quality and increase expected profit over the market clearing strategy. By “underpricing” high quality goods and offering a purchase option guaranteeing a single price regardless of quality, firms create excess demand and increase consumer willingness to pay for their purchase option. The firm maximizes profit by choosing a guaranteed price low enough to create sufficient excess demand and consumer willingness to pay for the purchase option that markets clear when quality is low. Using a numeric example, I demonstrate a case where this behavior increases profit over the market clearing strategy.
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To Pamela and Adrienne
Chapter 1

Introduction

This dissertation is comprised of three stand alone essays, each investigating disjoint topics. As a result the objective of this dissertation is three fold: (1) to consider and estimate the bilateral effects of tobacco regulations, (2) to estimate how different levels of access and excludability affect intrinsic quality of a common pool resource, and (3) to explain the phenomena of recurring excess demand in the wine industry.

1.1 Tobacco Regulation

Tobacco use is the cause of a host of adverse health effects and is responsible for the deaths of millions of people. The World Health Organization (WHO) estimates tobacco use kills 5 million people a year and projects tobacco consumption to continue increasing. Policy makers have attempted to address the tobacco epidemic using a variety of tobacco regulations. Although there has been much debate regarding tobacco regulation efficacy, little has been done to investigate their effects in a multilateral environment and how they affect trade flows.

In chapter 2, I develop a gravity equation incorporating a comprehensive set of domestic and foreign tobacco regulations into a country’s tobacco import demand and estimate their bilateral effects. I consider four categories of tobacco regulations — marketing regulations or bans, counter-advertising and education mandates, smoke-free or spatial regulations, and age restrictions. There are two important results. First, spatial regulations reduce tobacco imports and exports, regardless of trade direction. This suggests spatial regulations have a spillover effect. If a country implements spatial regulations in order to reduce tobacco consumption, and
they happen to be an exporting country, our results suggest they will export less tobacco on the world market. Second, marketing regulations in importing countries may actually increase tobacco imports. Tobacco exporting firms may target those countries with more stringent marketing regulations as it is less costly to compete and earn market share (Doraszelski and Markovich, 2007; Eckard, 1991; Qi, 2011; and Farr, et al., 2001). In an increasingly multilateral economy, these results highlight the importance of understanding tobacco regulations in a bilateral context.

1.2 Intrinsic Resource Quality

Although property rights are a central issue in natural resource economics, the literature has only recently considered their role in determining resource quality. The majority of this literature broadly defines quality through a degradation or extraction framework. Certain resources may have intrinsic quality characteristics not captured in a degradation-extraction framework. An intrinsic quality characteristic is a characteristic of the resource valued by the consumer. An example from the fisheries literature is the fat content or flesh composition of fish. Even with well defined property rights, a fugitive common pool resource exhibits market failures from a lack of excludability and other externalities.

Chapter 3 considers the effects of varying levels of access and excludability on a fugitive common pool resource with intrinsic quality characteristics. I analyze the case of deer hunting on leased properties by hunting clubs and estimate the lease size elasticity of both harvest and antler quality. The example of deer was chosen for three reasons. First, there is a thriving market for deer hunting in the US. In 2001, there were over 10 million deer hunters contributing
$27.8 billion to the US economy (IAFWA, 2002). Second, deer are highly differentiated in what hunters perceive as quality. Antler characteristics are paramount in determining a hunter’s perceived quality of the deer. Hunters prefer big antlered deer (Loomis, et al., 1989). For example, in Texas, where some of the largest antlered deer in the world are found, harvesting a trophy deer cost an average of $6,372 (Anderson, et al., 2007). Finally, I have a unique data set with quality information that has not been used in the economics literature (Strickland and Demarais, 2008). The results suggest lease size has a small but significant effect on both harvest and the average antler quality of deer. Given the increased interest in quality game management, these results may be of considerable interest to a variety of private landowners, businesses, hunting organizations, or state and federal wildlife agencies.

1.3 Excess Demand

Excess demand occurs when the quantity demanded exceeds the quantity supplied. The classic examples discussed are the long queues for popular restaurants or sold out venues for sporting events, plays, and concerts. Many economists have asked why these firms do not simply increase their prices to reduce queues and the number of turned away fans, all while increasing their profits. Various explanations involving social externalities, adverse selection, or quality signaling have been proposed. However, the previous literature ignores a mechanism often accompanying goods with recurring excess demand - the purchase option. A purchase option grants the consumer the right to purchase the good in future periods. Goods with purchase options and recurring excess demand often have an uncertain future quality.
In chapter 4, I develop the relationship between excess demand and purchase options and illustrate a mechanism allowing firms to smooth sales across periods with uncertain quality and increase expected profit over the market clearing strategy. I analyze an example of this mechanism in the wine industry where wineries distribute their wines using a wine list. The wine list guarantees a single price regardless of quality and allocates wine based on list rank, in a top-down fashion. The winery’s problem is to choose a wine list price such that it creates enough excess demand and consumer willingness to pay for the option that consumers are willing purchase wine for the guaranteed price when quality is low. Using a simulated wine list, I illustrate the winery can increase their expected profit over the market clearing levels by employing a wine list with positive excess demand.
Chapter 2
The Trade Effects of Tobacco Regulation

2.1 Introduction

Tobacco use is the cause of a host of adverse health effects and is responsible for the deaths of millions of people. The World Health Organization (WHO) estimates tobacco use kills 5 million people a year and projects tobacco consumption to continue increasing. Policy makers have attempted to address the tobacco epidemic using a variety of tobacco regulations. Although there has been much debate regarding their efficacy, little has been done to investigate their effects on trade. This chapter examines how both domestic and foreign tobacco regulations affect the flow of tobacco trade. We develop a gravity equation incorporating a comprehensive set of tobacco regulations into a country’s tobacco import demand and estimate their effects on trade.

We consider four categories of tobacco regulations — marketing regulations or bans, counter-advertising and education mandates, smoke-free or spatial regulations, and age restrictions. Marketing regulations restrict where and to what audiences tobacco can be advertised. Smoke-free and spatial regulations are regulations that prohibit smoking in public areas. Tobacco counter-advertising broadly includes any form of media used to promote a message contrary to the messages promoted by tobacco companies, such as health warnings or campaigns fighting the popular image of smoking.

The effects of these regulations on consumption have been the subject of much debate.\(^1\) The literature on marketing bans and restrictions is inconclusive with conflicting results. Using

\(^1\) For a comprehensive review of tobacco regulation literature see Chaloupka and Warner (2000).
\(^2\) See Chapman and Borland et al. (1999) for a survey of literature on the effects of smoke-free legislation on
panel data from a cross-section of OECD countries Laugesen and Meads (1991) and Saffer and Chaloupka (2000) find comprehensive marketing bans have a modest effect on adult tobacco use. Using similar data for OECD countries, Stewart (1993) and Nelson (2003a and 2003b) find no significant effect. However, there is a consensus that smoke-free and spatial regulations significantly reduce cigarette consumption. The counter-advertising literature is also in accord. From 1967 to 1970 broadcasting companies in the US were required to allocate air time to tobacco counter-advertising. These counter-advertising efforts were effective in significantly reducing tobacco consumption in the US (Lewit et al., 1981; Schneider et al., 1981; Warner, 1981; and Baltagi and Levin, 1986). Similar results have been found with local level data from California (Hu et al., 1995).

A country’s tobacco consumption may not only be affected by domestic tobacco regulations, but also foreign regulations. For example, assume more stringent tobacco regulations are introduced in a tobacco producing country. The literature suggests the increased regulations will, to some extent, reduce the domestic demand for tobacco. Due to the decreased domestic demand, tobacco firms may attempt to increase the consumption of their products in foreign markets. Doing so requires advertising and marketing efforts. The choice of where tobacco firms direct these efforts is likely determined in part by the regulation environments in foreign markets.

Regulations have different mechanisms and may affect trade flows differently. The age and spatial regulations reduce aggregate tobacco demand. Assuming they are enforced they effectively remove a portion of the consumer base and increase the opportunity cost of

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2 See Chapman and Borland et al. (1999) for a survey of literature on the effects of smoke-free legislation on cigarette consumption in the US and Australia.
consuming tobacco. The marketing and counter-advertising regulations may cause a shift in tobacco demand by altering consumer perceptions. Additionally, marketing regulations may actually reduce competition among tobacco firms (Doraszelski and Markovich, 2007; Eckard, 1991; Qi, 2011; and Farr et al., 2001). Strict marketing regulations decrease the marketing effort required to be competitive. Exporting tobacco firms may seek out those countries with strong marketing regulations. Although counter-intuitive, this behavior would result in increased trade flows to those countries with more stringent marketing regulations. In an increasingly global economy, understanding the effects of these different regulations on trade flows is crucial for developing meaningful tobacco policies. The goal of this chapter is to estimate these effects.

For decades the gravity equation has been a standard for predicting trade flows. It was first introduced by Tinbergen (1962). The theoretical foundation was developed by Anderson (1979). Before Anderson and van Wincoop’s (2003) seminal work, gravity equations were misspecified. The level of trade between a specific country pair is not solely determined by their trade costs. It is also influenced by the trade costs of all other trade partners. Anderson and van Wincoop (hence forth referred to as AvW) introduced the use of multilateral resistance terms that account these relative trade costs.

Economists have studied the effects of various other policies on tobacco consumption and trade. Studying the Andean Pact, Holden et al. (2010) find regional trade agreements significantly affect tobacco firms’ marketing, lobbying, and organizational strategies. Using time series data, Chaloupka and Laixuthai (1996) analyze the effect of opening markets in Japan, Thailand, South Korea, and Taiwan to US cigarettes. They find market shares for US cigarettes

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3 One could argue that spatial regulations also reduce the consumer base, as certain consumers may only like smoking in certain areas like bars or restaurants.
dramatically increase and estimate aggregate per capita cigarette consumption was ten percent higher than it would have been without the trade liberalization. Stoforos and Mergos (2004) study the impact of eliminating tobacco production subsidies in the European Union as a means to lower consumption. Although they find tobacco consumption would initially fall, tobacco production would simply shift to foreign countries and tobacco imports would significantly increase. They note a policy designed to reduce tobacco consumption should focus on reducing demand.4

This issue is related to an idea from the international economics literature referred to as the pollution haven hypothesis (PHH). The PHH originated from the debate over the environmental consequences of NAFTA (Grossman and Krueger, 1993 and 1995). The PHH suggests if a country has very strict regulations, the firm’s cost of environmental regulation compliance is high and the firm may have an incentive to relocate to a country with less stringent environmental regulations.5 The mechanism driving the PHH is strictly supply oriented. The underlying mechanism driving the effects of regulations on tobacco trade stems from both supply and demand.

This chapter has three important contributions. First, there is a lack of literature analyzing the effects of tobacco regulations on tobacco trade. We address the gap and offer an alternative perspective on the efficacy of tobacco regulations. Second, spatial regulations reduce tobacco imports and exports, regardless of trade direction. Third, marketing regulations may actually increase tobacco imports. These results have important policy implications. There is

4 For additional literature on the effects of economic policies on tobacco production see Pena and Norton (1993).
5 A simple two country model illustrating the PHH is outlined in Copeland and Taylor (1994). Taylor (2004) gives a comprehensive exposition of the mechanism behind the PHH. Empirical tests have shown weak or no support for the PHH (Jaffe et al., 1995; Antweiler et al., 2001; Baggs, 2009).
strong evidence to support increasing spatial regulations, regardless of trade direction. This is especially true for developing countries, which tend to have lower levels of these regulations. Increased imports due to strict marketing regulations may shift the demand away from domestic producers. Additionally, if increased tobacco imports from strict marketing regulations lead to increased consumption, the impact of these policies on social welfare may need to be reevaluated.

2.2 Model

Our model is an adaptation of AvW’s gravity equation. We make an additional assumption to AvW’s derivation of the gravity equation. As the literature suggests, we assume certain types of domestic and foreign tobacco regulations affect tobacco demand. We incorporate these regulations into AvW’s gravity equation.

We begin with a representative consumer who maximizes a constant elasticity of substitution utility function subject to a budget constraint. We assume an $n$ country world where consumers in country $j$ import and consume country $i$’s goods. Each country produces differentiated tobacco, which is either consumed domestically or in foreign markets.

The utility function for country $j$’s consumer is given by,

$$U_j(c_{ij}) = \left[ \sum_{i=1}^{n} \left( \frac{c_{ij}}{\beta_i} \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}},$$

where $c_{ij}$ is consumer $j$’s consumption of country $i$’s goods, $\beta_i$ is the share parameter for country $i$’s good, and $\sigma$ is the elasticity of substitution. The consumer’s budget constraint takes the following form,
\[ y_j = \sum_{i=1}^{n} p_i c_{ij}, \quad (2) \]

where \( y_j \) is country \( j \)'s total income and \( p_i \) is the price country \( j \)'s consumers face for country \( i \)'s goods. Assuming a three country model, the Lagrangian maximizing (1) subject to (2) yields the following first order conditions:

\[
\frac{\partial L}{\partial c_{ij}} = \left( \frac{\sigma}{\sigma-1} \right) \left[ \sum_{i=1}^{n} \left( \frac{c_{ij}}{\beta_i} \right) \right]^{-\frac{\sigma}{\sigma-1}} \left( \frac{1}{\beta_i} \right)^{\frac{\sigma}{\sigma-1}} \left( \frac{\sigma-1}{\sigma} \right) \left( c_{ij} \right)^{\frac{1}{\sigma}} - \lambda p_{ij} = 0
\]

\[
\frac{\partial L}{\partial c_{kj}} = \left( \frac{\sigma}{\sigma-1} \right) \left[ \sum_{i=1}^{n} \left( \frac{c_{ij}}{\beta_i} \right) \right]^{-\frac{\sigma}{\sigma-1}} \left( \frac{1}{\beta_j} \right)^{\frac{\sigma}{\sigma-1}} \left( \frac{\sigma-1}{\sigma} \right) \left( c_{ij} \right)^{\frac{1}{\sigma}} - \lambda p_{kj} = 0
\]

\[
\frac{\partial L}{\partial \lambda_j} = y_j - \sum_{i=1}^{n} p_i c_{ij} = 0
\]

Solving the first order conditions yield country \( j \)'s demand for country \( i \)'s goods,

\[
x_{ij} = y_j \left( \frac{\beta_i p_{ij}}{\sum_{i=1}^{n} \beta_i p_{ij}} \right)^{1-\sigma}.
\quad (3)
\]

The prices country \( j \) face, \( p_{ij} \), are very different than the domestic prices in country \( i \). Trade costs and frictions are partially responsible for these price differences. Gravity theory uses a pass through function to model the affect of these trade costs and frictions. We incorporate domestic and foreign tobacco regulations into the pass through function. The domestic regulations affect the foreign tobacco firm’s ability to increase demand and prices for their
products, while the foreign regulations affect the supply of the foreign tobacco available for import.

We create a set of regulation indices to measure regulation intensity. Let $r_i^c$ be the counter-advertising, $r_i^m$ the advertising, $r_i^a$ the age regulation index, and $r_i^s$ the spatial regulation indices for country $i$. Let $cntr_i$, $m_i$, $s_i$, and $a_i$ be the counter-advertising, advertising, age, and spatial regulation sensitivity parameters for the exporting country $i$. Country $j$ has a similar set of regulation indices and sensitivity parameters.

Write the effects of regulations as,

$$ R_{ij} \Phi = r_i^c cntr_i + r_i^m m_i + r_i^a a_i + r_i^c cntr_j + r_j^m m_j + r_j^a a_j, $$

where $\Phi$ is the $8 \times 1$ vector of parameters sensitivities and $R_{ij}$ is the $1 \times 8$ vector of regulation indices. Let $t_{ij}$ be the per unit trade costs between country $i$ and country $j$. Using the pass through function, the price of foreign goods takes the following form,

$$ p_{ij} = e^{(R_{ij} \Phi)} p_{ij}, $$

where $p_i$ is the exporter’s supply price on the world market. Substituting (4) into (3) yields the following tobacco import demand,

$$ x_{ij} = y_j \left[ \frac{e^{(R_{ij} \Phi)} p_{ij} t_{ij}}{P_j} \right]^{1-\sigma}, $$

where $P_j$ is a price index term defined as,
\[ P_j = \left[ \sum_{i=1}^{n} \left( e^{(R_{ij})} \beta_i p_i t_{ij} \right) \right]^{1-\sigma}. \] (6)

From the market clearing condition, we are able to solve for the scaled prices and substitute them into (5). After some algebraic manipulation, we have the following demand, \(^6\)

\[ x_{ij} = \frac{y_j y_i}{y_w} \left[ e^{(R_{ij})} \frac{t_{ij}}{P_j \Pi_i} \right]^{1-\sigma}, \] (7)

where

\[ \Pi_i = \left\{ \sum_{j=1}^{n} \frac{y_j}{y_w} \left[ e^{(R_{ij})} \frac{t_{ij}}{P_j} \right]^{1-\sigma} \right\}^{1 \over 1-\sigma} \] (8)

and

\[ P_j = \left\{ \sum_{i=1}^{n} \frac{y_i}{y_w} \left[ e^{(R_{ij})} \frac{t_{ij}}{\Pi_i} \right]^{1-\sigma} \right\}^{1 \over 1-\sigma}. \] (9)

\( P_j \) and \( \Pi_i \) are referred to as inward and outward multilateral resistance terms (AvW, 2003). They account for the trade resistance among all trading partners. Let trade costs be specified as,

\[ t_{ij} = e^{\gamma_{CUL} b} d_{ij}^b (1+t_{ij}), \] (10)

where \( CUL \) is a vector of cultural and geological characteristics, \( d_{ij} \) is the distance between country \( i \) and \( j \), \( b \) is a trade elasticity of distance, and \( t_{ij} \) is country \( j \)'s ad valorem import tariff on country \( i \)'s goods. Substituting (10) into (7), we rewrite demand as

\(^6\) See appendix 2.1 for a detailed exposition.
\[ x_{ij} = \frac{y_{ij} y_i}{y_w} \left[ e^{(R_i \Phi)} e^{\gamma \text{CUL}_{ij}} d_{ij}^b (1 + b f_{ij}) \right]^{1-\sigma}. \] (11)

Taking the log of (11) yields the gravity equation,

\[
\ln x_{ij} = \ln \left( y_{ij} \right) + \ln \left( y_i \right) + \ln \left( y_{w} \right) + (1 - \sigma) R_i \Phi + (1 - \sigma) \gamma \text{CUL}_{ij}
+ (1 - \sigma) \ln \left( 1 + tf_{ij} \right) + (1 - \sigma) b \ln d_{ij} - \ln \Gamma_i^{1-\sigma} - \ln P_i^{1-\sigma}. \] (12)

We hypothesize counter-advertising regulations increase tobacco exports while decreasing tobacco imports. Initially, one might hypothesize import marketing regulations would reduce imports. However, based on the literature suggesting marketing regulations decrease competition, we hypothesize tobacco exporting firms actually target those countries with strict marketing regulations and that countries with higher levels of marketing regulations will import more.\(^7\) Alternatively, strict marketing regulations in exporting countries may free up resources that otherwise would have been spent marketing, allowing them to export more. If marketing regulations are effective in reducing consumption, there will also be an increased supply available for export. Therefore, we hypothesize exporter marketing regulations increase exports.

Age and spatial regulations reduce the aggregate demand and we hypothesize they reduce tobacco imports. These regulations also increase the quantity of tobacco available for export. However, age and spatial regulations may actually reduce exports. For example, assume certain American brands are popular in a foreign market because they are widely consumed by young people in the US. If age and spatial regulations are passed in the US and the brands become less

widely consumed domestically, foreign markets may respond by demanding less too. Additionally, the reduced aggregate demand within the exporting country may reduce the resources available to the firm for increasing the demand of their product in foreign markets. The total effect of age and spatial regulations depends on which effects dominate.

The regulations have two separate effects on a country’s tobacco import demand. The first is the direct effect, found in the fourth term on the RHS of (12). The second is the indirect effect which is captured in (8) and (9) by the multilateral resistance terms. A country’s tobacco import or export decision is influenced by the regulations of all other countries. The decision does not solely depend on the trading partners regulations. The direct and indirect effects can be distinguished when looking at the elasticity of regulations. The elasticity of an exporter’s regulation is given by,

\[ \xi_i = \frac{\widehat{\partial X_{ij}^*}}{\partial r_i} \frac{r_i}{x_{ij}}. \]

We can separate the elasticity effect into the sum of the direct and indirect effects as follows,

\[ \xi_i = (1 - \sigma) \frac{\widehat{\partial \Phi R_{ij}^*}}{\partial r_i} r_i + \left( \frac{\widehat{\partial \Pi_i P_{ij}^{(\sigma - 1)}}}{\partial r_i} \right) r_i. \]

The first term on the RHS is the direct effect. The second term on the RHS is the indirect effect.

2.2.1 Estimation

Estimating (12) presents a number of obstacles. First, the multilateral resistance terms are not directly measurable from the data. Because AvW were concerned with the parameter estimates of the multilateral resistance terms, they implement a complex algorithm to simulate them. Rather than simulating them, they can be proxied using a fixed effects approach by including
country specific dummies (AvW, 2003, Feenstra, 2004). We use the fixed effects approach. This aggregates the direct and indirect regulation effects into the estimated coefficients. The fixed effects capture all remaining unobserved trade resistances.

Second, tariff data are only observable if trade occurs. This creates a large truncation issue as we have a large number of observations with zero trade. To circumvent these issues, we use a proxy for tobacco tariffs. We use a country specific trade freedom index that captures both tariff and non-tariff barriers to trade.

Finally, gravity equations are typically estimated using log-linear form. Using a data set with all possible trading partner combinations there is unavoidably going to be a large number of zero trade flows. Taking the log of trade would create missing values for these observations and ignore a large amount of important information. Two common estimation strategies involve either dropping observations with zero trade or using \((x_{ij} + 1)\) and estimating via OLS. Neither approach is desirable, as both produce inconsistent estimates. Various empirical strategies have been developed to address the zeros problem.

process used in their simulations was not appropriate for modeling trade (Silva and Tenreyro, 2011). When data is generated using a constant elasticity model and the probability of observing zero is not independent of the regressors, the PPML estimator is favorable over the Tobit (Silva and Tenreyro, 2011).

Using the PPML estimator, we estimate our gravity equation in levels rather than the log-linearized form. Rewriting (12) in levels yields,

\[ x_{ij} = \exp \left[ \ln \left( y_i \right) + \ln \left( y_j \right) - \ln \left( y_w \right) + (1-\sigma)R_j \Phi + (1-\sigma)\gamma CUL_{ij} \right] + (1-\sigma)\ln \left( 1 + tf_{ij} \right) + (1-\sigma)b_1 \ln d_{ij} - \ln \prod_{i}^{1-\sigma} - \ln P_{i}^{1-\sigma} . \]  

(13)

Letting \( k \) index the \( ij \)th bilateral country pair, \( Z_k \) be the vector of the covariates for country pair \( k \), and \( \Theta \) be the vector of parameters to be estimated from (13), our gravity equation can be expressed as

\[ x_k = \exp[\Theta Z_k] . \]  

(14)

The resulting Poisson log-likelihood function is given by

\[ \ln L = \sum_{k}^{n(n-1)} \left( -e^{\Theta Z_k} + \Theta Z_k x_k - \ln x_k ! \right) , \]  

(15)

where \( n \) is the number of countries. The PPML estimates of (15) can be estimated by solving the following set of first order conditions,

\[ \sum_{k}^{n(n-1)} \left[ x_k - \exp(\Theta Z_k) \right] \hat{z}^h_k = 0 , \quad \forall \ h = 1, 2, \ldots, H , \]  

(16)
where \( H \) is the number of covariates, and \( z_h^k \) is the \( h \)th covariate. The data can be a non-integer valued and need not be Poisson distributed.\(^8\) Consistency depends on the correct specification of the conditional mean of trade, \( E[x_k | Z_k] = e^{\theta Z_k} \) (Silva and Tenreyro, 2010).

2.3 Data

Our analysis uses cross-sectional data from the year 2000. The information includes tobacco trade flows, a trade freedom index, per capita GDP, country specific tobacco regulations, and bilateral distances and characteristics. Table 2.1 presents the data sources.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco trade</td>
<td>World Bank’s COMTRADE data set</td>
</tr>
<tr>
<td>GDP</td>
<td>World Bank</td>
</tr>
<tr>
<td>Trade freedom index</td>
<td>Heritage Foundation</td>
</tr>
<tr>
<td>Tobacco regulations</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>Bilateral distances</td>
<td>Centre d’Etudes Prospectives et d’Informations Internationales</td>
</tr>
</tbody>
</table>

The trade data includes total import values of manufactured and unmanufactured tobacco from the year 2000. The values are in thousands of US dollars. There are 2,571 observed positive trade flows. Zero trade is not reported. Using the observed trade values, we build a dataset including all possible trading partners. There are 160 importing countries and 147 exporting countries, yielding 160x147 total observations.

The information on regulations includes three levels of regulation — bans and complete restrictions, partial regulation, and not regulated. Only complete bans and restrictions are considered in our analysis. Table 2.2 lists the regulations by category included in the model. Each country has a set of indices to measure the level of regulation. There are only two counter-

---

\(^8\) A maximum likelihood estimate is considered a pseudo- maximum likelihood estimate when it is consistent even under misspecification (Winkelmann, 2003).
advertizing regulations. Rather than use an index with two regulations, we use a dummy variable to indicating whether either counter-advertising regulation is present. For the other regulation types, indices were created by summing the number of regulations observed for each category and dividing the sum by the total number of regulations in each category. Each regulation within the index is equally weighted. This normalizes the index between zero and one. For example, a country with the highest level of regulation will have an index of 1. Similarly, a country with zero regulations will have an index of 0.

The trade freedom index is a broad measure of trade barriers. It include both tariff and non-tariff measures. The formula used to calculate the index consists of two parts. The first is a score based on the trade-weighted average tariff and the maximum tariff. The second is a penalty deducted from the first for non-tariff barriers. A perfectly open economy would have an index of 100.

Bilateral distances were calculated using the great circle formula. The cultural and geographic characteristics include three dummy variables indicating whether the countries share a border, a common language, or a colonial link. After removing observations with missing values and countries that never import or export, we have 9,560 total observations. Table 2.3 presents the summary statistics.

---

9 For a detailed exposition see http://www.heritage.org/index/trade-freedom
### Table 2.2 Regulation Indices

<table>
<thead>
<tr>
<th>Counter-advertising regulation index</th>
<th>Marketing regulation index</th>
<th>Age regulation index</th>
<th>Spatial regulation Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandated education</td>
<td>Marketing in certain media</td>
<td>Sales to minors</td>
<td>Smoking in government buildings</td>
</tr>
<tr>
<td>Mandated health warnings</td>
<td>Marketing to certain audiences</td>
<td>Age verification for sales</td>
<td>Smoking in private worksites</td>
</tr>
<tr>
<td></td>
<td>Marketing in certain locations</td>
<td>Vending machines sales</td>
<td>Smoking in educational facilities</td>
</tr>
<tr>
<td></td>
<td>Sponsorship or promotion for certain audiences</td>
<td>Free tobacco products</td>
<td>Smoking in health care facilities</td>
</tr>
<tr>
<td></td>
<td>Sponsorship marketing of events</td>
<td></td>
<td>Smoking on buses</td>
</tr>
<tr>
<td></td>
<td>Brand stretching</td>
<td></td>
<td>Smoking on trains</td>
</tr>
<tr>
<td></td>
<td>Misleading information on packaging</td>
<td></td>
<td>Smoking in taxis</td>
</tr>
<tr>
<td></td>
<td>Package health warning/message</td>
<td></td>
<td>Smoking on ferries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Smoking on domestic air flights</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Smoking on international flights</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Smoking in restaurants</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Smoking in nightclubs and bars</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Smoking in other public places</td>
</tr>
</tbody>
</table>

### Table 2.3 Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>St. Dev</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco Imports</td>
<td>1459</td>
<td>28978</td>
<td>0.0000</td>
<td>2539341</td>
</tr>
<tr>
<td>Log of exporter per capita GDP</td>
<td>8.8626</td>
<td>1.0567</td>
<td>6.5276</td>
<td>10.7835</td>
</tr>
<tr>
<td>Log of importer per capita GDP</td>
<td>8.8676</td>
<td>1.0789</td>
<td>6.2420</td>
<td>10.7835</td>
</tr>
<tr>
<td>Log of trade freedom index</td>
<td>4.1541</td>
<td>0.2873</td>
<td>2.7081</td>
<td>4.4998</td>
</tr>
<tr>
<td>Exporter advertising regulation index</td>
<td>0.2439</td>
<td>0.2074</td>
<td>0.0000</td>
<td>0.8000</td>
</tr>
<tr>
<td>Exporter age regulation index</td>
<td>0.2310</td>
<td>0.2317</td>
<td>0.0000</td>
<td>0.8000</td>
</tr>
<tr>
<td>Exporter spatial regulation index</td>
<td>0.2716</td>
<td>0.2418</td>
<td>0.0000</td>
<td>0.9231</td>
</tr>
<tr>
<td>Importer advertising regulation index</td>
<td>0.2519</td>
<td>0.2052</td>
<td>0.0000</td>
<td>0.8000</td>
</tr>
<tr>
<td>Importer age regulation index</td>
<td>0.2318</td>
<td>0.2362</td>
<td>0.0000</td>
<td>0.8000</td>
</tr>
<tr>
<td>Importer spatial regulation index</td>
<td>0.2310</td>
<td>0.2317</td>
<td>0.0000</td>
<td>0.8000</td>
</tr>
</tbody>
</table>

### 2.4 Results

The results are presented in the first column of table 2.4. The exporter and importer GDP coefficients are positive and statistically significant. Gravity theory suggests larger countries trade more and that the GDP coefficients are equal to one. We fail to reject a t-test of the hypothesis that both exporter and importer GDP coefficients are equal to one. The theory also
states that trade costs reduce trade flows. Recall the trade freedom index increases as the economy becomes more open. The trade freedom index and distance coefficients are positive and negative as hypothesized. Both are statistically significant. However, none of the bilateral characteristics of sharing a border, a common language, or a colonial link are statistically significant.

Consider the exporter regulation coefficients. The counter-advertising coefficient is positive and statistically significant suggesting counter-advertising mandates increase exports. The marketing coefficient is also positive and statistically significant. Following intuition, this suggests exporting countries with more marketing regulation export more tobacco. The age regulation coefficient is not statistically significant. This may be an enforcement issue. Although many countries have age regulations, they may not be effectively enforced. The spatial regulation coefficient is negative and statistically significant. This suggests an exporting country with strict spatial regulations will export less than a country with less stringent spatial regulations. This is an interesting result. The literature suggests implementing spatial regulations is an effective means to reduce tobacco consumption.\(^{10}\) However, this result suggests there may be a spillover effect. If spatial regulations are passed doing so in a tobacco exporting country also reduces tobacco exports, this reduces the supply of tobacco on the world market.

Now consider the importing country regulations. The counter-advertising regulation coefficient is not statistically significant. The marketing regulation coefficient is positive and statistically significant. This suggests countries with more marketing regulations import more tobacco. This is a striking result. This result supports the notion that tobacco exporting firms

\(^{10}\) See Chapman and Borland et al. (1999) for a survey of literature on the effects of spatial regulations on cigarette consumption in the US and Australia.
export more to countries with marketing regulations. As suggested by the literature, one explanation for this result may be reduced competition within those countries. The advertising and marketing expenditures required to make a brand known and earn market share in a foreign market is likely lower in countries with more stringent marketing regulations. As a result, exporting firms may target such markets for their exports.

The age regulation coefficient is not statistically significant. The spatial regulation coefficient is negative and statistically significant. Following intuition, this suggests an importing country with strict spatial regulations will import less than a country with less stringent spatial regulations. The correlation between importer GDP and spatial regulation indices is 0.1872, suggesting developing countries may have lower levels of these regulations.

To better understand the impact of the regulations, we simulate a policy change to measure the effect on tobacco imports. We consider the effects of importer marketing and exporter spatial regulations. There are 4141 observations where the importing country has higher than average marketing regulations. For this subsample we simulate a decrease to the average level of marketing regulation. The simulated decreases in importer marketing regulations decreases the expected value of tobacco imports by 70 percent. There are 4850 observations where the exporter employs few than the average spatial regulations. For this subsample a simulated increase to the average reduces the expected exports by 61 percent. Next, we focus on specific countries. France is the second largest importer of tobacco with over $1.4 billion in tobacco imports. Out of the eight marketing regulations we consider, they employ five. A simulated reduction to four marketing regulations results in a decrease in their tobacco imports of over 50 percent. The Netherlands is the second largest exporter of tobacco with over $2.6
billion in total exports. They do not employ any spatial regulations. Simulating an increase to one spatial regulation reduces their exports by 32 percent.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Full sample</th>
<th>Dropping top 50 residuals subsample</th>
<th>Large income gap subsample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log of exporter per capita GDP</td>
<td>1.2206 (0.2635)**</td>
<td>1.5270 (0.2149)***</td>
<td>1.1955 (0.2310)***</td>
</tr>
<tr>
<td>Log of importer per capita GDP</td>
<td>1.2734 (0.2859)**</td>
<td>1.6950 (0.2342)***</td>
<td>1.9903 (0.2371)***</td>
</tr>
<tr>
<td>Log of trade freedom index</td>
<td>1.8133 (1.0799)*</td>
<td>1.4265 (0.8919)***</td>
<td>0.5014 (0.8637)</td>
</tr>
<tr>
<td>Contiguous</td>
<td>0.2270 (0.5980)</td>
<td>0.3947 (0.3307)***</td>
<td>2.1390 (0.6070)***</td>
</tr>
<tr>
<td>Common language</td>
<td>0.4524 (0.3109)</td>
<td>0.4820 (0.2686)*</td>
<td>0.7802 (0.4256)*</td>
</tr>
<tr>
<td>Common Colony</td>
<td>-0.2558 (0.4002)</td>
<td>0.3361 (0.3869)</td>
<td>-0.4462 (0.3200)</td>
</tr>
<tr>
<td>Log of distance</td>
<td>-0.8752 (0.1859)***</td>
<td>-1.0910 (0.1302)***</td>
<td>-0.5243 (0.1517)***</td>
</tr>
<tr>
<td>Exporter Counter-advertising regulation index</td>
<td>2.0664 (0.5793)***</td>
<td>2.3091 (0.5535)***</td>
<td>1.4787 (0.5563)***</td>
</tr>
<tr>
<td>Exporter Marketing regulation index</td>
<td>7.9251 (1.1785)***</td>
<td>9.1389 (1.0937)***</td>
<td>12.5825 (1.4705)***</td>
</tr>
<tr>
<td>Exporter Age regulation index</td>
<td>-0.7001 (1.2763)</td>
<td>-0.4876 (1.2979)</td>
<td>1.9834 (1.5408)</td>
</tr>
<tr>
<td>Exporter Spatial regulation index</td>
<td>-5.0513 (0.9404)***</td>
<td>-6.3450 (1.0171)***</td>
<td>-6.9212 (1.1180)***</td>
</tr>
<tr>
<td>Importer Counter-advertising regulation index</td>
<td>0.7973 (0.5637)</td>
<td>0.8320 (0.5378)</td>
<td>-0.0321 (0.5669)</td>
</tr>
<tr>
<td>Importer Marketing regulation index</td>
<td>6.3595 (0.9663)***</td>
<td>7.8137 (1.0651)***</td>
<td>9.3511 (1.4093)***</td>
</tr>
<tr>
<td>Importer Age regulation index</td>
<td>0.4290 (1.0597)</td>
<td>0.7990 (1.1284)</td>
<td>1.5863 (1.3393)</td>
</tr>
<tr>
<td>Importer Spatial regulation index</td>
<td>-2.3832 (0.8577)***</td>
<td>-2.7744 (0.8425)***</td>
<td>-3.1064 (0.8334)***</td>
</tr>
<tr>
<td>Country Specific Dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* = significance at the 10% level
** = significance at the 5% level
*** = significance at the 1% level
2.4.1 Robustness

We perform two robustness checks. There are a few observations with extremely large residuals. We re-estimate (13) using a subsample that excludes the top fifty residuals. The results are shown in the second column of table 2.4. Considering the possible policy implications for developing countries, we re-estimate (13) using a subsample with a large positive income gap between the exporting and importing country. The subsample only includes observations where export per capita GDP exceeds importer per capita GDP by $10,000 or more. The results are in the third column of table 2.4. The regulation coefficients maintain their signs and significance for both subsamples.

2.5 Concluding Remarks

Given the consumption of tobacco is projected to continue rising worldwide, addressing the epidemic of tobacco related disease must remain a priority for policy makers. Although there has been much debate regarding their efficacy, little has been done to investigate their bilateral effects. In this chapter I use a gravity equation to estimate the bilateral effects tobacco regulations. For certain regulations, we find these effects are significant in determining the flow of tobacco trade. There are two striking results with important policy implications.

First, spatial regulations may not only decrease tobacco imports but also tobacco exports. This suggests spatial regulations have a spillover effect. If a country implements spatial regulations in order to reduce tobacco consumption, and they happen to be an exporting country, our results suggest there will be less tobacco on the world market. This makes a strong case for a unilateral increase in spatial regulations to decrease trade flows of tobacco. Developing countries generally have lower levels of these regulations. If they can be effectively enforced,
these regulations offer developing countries a simple policy tool that may reduce tobacco imports.

Second, importer marketing regulations appear to increase tobacco imports. Tobacco exporting firms may target those countries with more stringent marketing regulations as it is less costly to compete and earn market share. From a policy maker’s perspective, this presents a number of complicated questions. What are societal impacts in terms of consumption? Does this “crowd out” domestic market share and if so, what are the tax and employment consequences?

A possible extension could investigate the flow of advertising expenditures to further test whether increased marketing regulations attract foreign firms.
Chapter 3

The Direct and Indirect Effects of Lease Size on Big Game Quality

3.1 Introduction

The theory of property rights in the exploitation of natural resources has been the focus of economists for decades. Without well defined property rights, externalities are not internalized, resources tend to be overused, and economic rents dissipate (Gordon, 1954; Scott, 1955; Coase, 1960; Hardin, 1968). Only recently has the literature begun to consider the role of property rights in determining resource quality. The majority of this literature broadly defines quality through a degradation or extraction framework. However, certain resources may have intrinsic quality characteristics not captured in the degradation-extraction framework.

An intrinsic quality characteristic is a characteristic of the resource valued by the consumer. An example from the fisheries literature is the fat content or flesh composition of fish. The values consumers place on intrinsic quality characteristics create an incentive to internalize their value in management decisions. The ability of resource managers to internalize the value of these characteristics depends on their ability to exclude other from its use. Even with well defined property rights, a fugitive common pool resource exhibits market failures from a lack of excludability and other externalities. This chapter considers the effects of varying levels of access and excludability on a common pool resource with intrinsic quality characteristics.

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11 There is a wealth of literature on common pool resources. See Ostrom (1991) or Stevenson (1991) for comprehensive reviews.
The first attention given to the management issues of intrinsic quality characteristics is found in the shellfish literature. A number of studies suggest altering season timings may lead to harvesting larger individuals and increased prices (Conrad, 1982; Anderson, 1989; Kellogg et al., 1988). Extending the analysis to consider intraseasonal adjustments in the Pacific Whiting fisheries, internalizing intrinsic quality characteristics and timing harvest to coincide with seasonal changes in flesh compositions improved net industry revenues (Larkin and Sylvia, 1999; Larkin and Sylvia, 2004). The levels of access and excludability are not considered in these works, and we are not aware of any literature estimating their effects on intrinsic resource quality.

We analyze the case of deer exploitation on leased properties by hunting clubs. The example of deer was chosen for three reasons. First, there is a thriving market for deer hunting in the US. In 2001, there were over 10 million deer hunters contributing $27.8 billion to the US economy (IAFWA, 2002). Second, deer are highly differentiated in what hunters perceive as quality. Antler characteristics are paramount in determining a hunter’s perceived quality of the deer. Hunters prefer big antlered deer. For example, in Texas, where some of the largest antlered deer in the world are found, harvesting a trophy deer cost an average of $6,372 (Anderson et al., 2007). Finally, we have a unique data set with quality information that has not been used in the economics literature.

Antlers are only developed by male deer. There are a number of determinants of antler size. Antler development is primarily a function of age, nutrition, and genetics. Assuming adequate nutrition, antler size increases significantly with age (Jacobson, 1995). Throughout the rest of this chapter antler size is referred to as quality, and unless otherwise stated we are
referring to male deer. A simple way to improve the average quality of deer harvested is to pass up hunting opportunities of the younger lower quality deer. This allows the stock of deer to age and increase in quality. In order to accomplish this, very specific management strategies must be implemented. However, because deer are a fugitive resource, a number of issues arise. The range of a stock of deer may not be contained within a single piece of land leased for hunting. If the range is located over multiple leases where the clubs are not collaborating, the stock is a common pool resource among the lessees. This limits the clubs’ ability to exclude others from its use and creates a number of negative externalities.

A negative externality is a cost not internalized by the responsible agent. When a deer is harvested from a common pool stock, that deer is no longer available for harvest by other hunters. An externality in the form of a lost hunting opportunity is imposed on the other hunters. Had the deer not been harvested, it would have continued to age and grow. As deer age and grow, antler quality significantly increases. This potential future increase in antler quality is an opportunity cost of harvest. Additionally, deer respond to human behavior. Hunting activity creates “pressure” on the stock. This may cause deer to become more alert and difficult to harvest (Holsworth, 1973 and Kufeld et al., 1986). One club’s hunting activity will affect the ability of other clubs to harvest. Clubs only leasing a portion of the stock’s range will not necessarily internalize the externalities they create. When externalities are not internalized, resources are not managed optimally (Hardin, 1968).

---

12 Body mass may also be a characteristic valued by hunters. However, because deer are not priced by body mass and are frequently priced based on antler quality, we focus on antler quality as the determinant of quality.

13 Our model and the data analyzed do not allow for high fences to prevent movement across property.

14 There are also non-consumptive benefits to wildlife. Certain consumers may derive utility from simply viewing a deer. Harvesting also imposes an externality on these types consumers.
The portion of a stock’s range leased by a club determines the extent to which the club is able to exclude others from its use. Additionally, it determines whether clubs internalize the externalities they create and the level of their exposure to externalities created by others. This affects club management decisions. As a club’s leased portion of the stock increases, excludability increases and the likelihood of experiencing externalities decreases. With increased excludability and a decreased likelihood of externalities, the club becomes more patient and willing to pass up younger lower quality deer, as the marginal return of harvesting in the future has increased. This type of selective harvesting will be evident in the club harvest per acre. The aim of this paper is to answer the following questions: (1) is harvest per acre decreasing with lease size and (2) do clubs with larger leases harvest a higher average quality deer?

The economics literature has not ignored big hunting game quality. A number of hedonic studies have estimated the role of big game quality in determining prices for hunting access (Livengood, 1983; Balkan and Kahn, 1988; Buscena et al. 2001). However, their measures of quality are success rates, densities of big game, and subjective ratings. Loomis et al. (1989), Cooper (1993), and Standiford and Howitt (1993) were the first to recognize and quantify the fact that hunters are willing to pay more for bigger antlered deer. On the county level, antler quality has been used to explain differences in lease prices (Munn and Hussain, 2010). Assuming monopolized access to the resource, Naevdal et al. (2012) attempt to incorporate

---

15 Lueck (1991) draws the connection between the portion of a stock’s range controlled, wildlife value, density, and the likelihood of selling hunting leases. He attributes the first implication to the fact that as the size of landholdings increase, the cost of establishing rights over the wildlife decrease.
quality into a bioeconomic model of trophy elk hunting. Measuring quality as the number of male elk in the stock, their analysis ignores the very intrinsic quality characteristic responsible for the majority of trophy hunting in the first place — antler quality.

We develop a bioeconomic model incorporating both lease size and antler quality. Our model illustrates how lease size and the quantity-quality trade-off affect club management decisions. We show lease size has direct and indirect effects on antler quality. The direct effect results from increased club “patience” due to increased excludability and less exposure to externalities. The indirect effects stem from the effects of lease size on stock and harvest rates. The total effect depends on the relationship between the magnitudes of the direct and indirect effects.

Using time-series cross-sectional data from Mississippi hunting clubs, we estimate the effect of lease size on harvest and quality. Our results suggest lease size has a small but significant effect on both harvest and the average antler quality of deer harvested. For all clubs with smaller than average hunting leases, a simulated increase to the average size results in approximately a 4.5 percent increase in the average antler quality of deer harvested. Given the increased interest in quality game management, these results may be of considerable interest to a variety of private landowners, businesses, hunting organizations, or state and federal wildlife agencies.\(^{16}\)

The remainder of this chapter is organized as follows. Section 3.2 presents a bioeconomic model developing the relationship between lease size, harvest, and quality outcomes. Section 3.3 introduces the data used in our empirical analysis. Section 3.4 describes

\(^{16}\) In Texas alone, breeding trophy bucks is a $650 million industry (Anderson et al. 2007).
our identification and estimation strategies. Results and discussion are found in section 3.5.
Concluding remarks are given in section 3.6.

### 3.2 Model

In the US, property rights for deer and other big game animals reside with states. Individuals may purchase rights to harvest deer in specific seasons, locations, and quantities. In order to harvest deer, the hunter must have access to deer inhabited lands. Public lands are available. However, they are often over used and crowded during hunting seasons. By selling access rights, private landowners capitalize on the deer inhabiting their lands. These access rights are referred to as hunting leases. Landowners either sell a number of individual leases or exclusively lease their entire property. To exclusively lease an entire property, individuals often form hunting clubs. Hunting club behavior can be generalized into three stages:

1. **The organization stage.** In the organization stage, the number of hunting clubs and their respective memberships are exogenously determined. Endogenous club formation and membership is a complex topic beyond the scope of this chapter.\(^\text{17}\)

2. **The leasing stage.** Only lands inhabited with a stock of deer are leased. Stock information is available *a priori*. Leases are exogenously determined and constant. In reality, leasing is endogenously determined by the quantity and quality of deer inhabiting the lands. However, we are interested in the management decisions of hunting clubs that maintain exclusive leases for the

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\(^{17}\) There is a rich literature addressing the economics of club formation. The first theory arose from Buchanan (1965). See Ahn et al. (2008) for a model of endogenous group formation.
same property. Under this framework the hunting club becomes the residual claimant, rather than the landowner.\(^{18}\)

(3) The harvest stage. In the harvest stage, clubs make their management decisions and harvest the stock of deer. Subject to state regulations, clubs manage the stock of deer according to their interests. Our analysis focuses on this final stage.

3.2.1 \textit{Harvest}

Assume the hunting club has formed and leased a property with deer inhabiting the lands. Denote the club’s lease size \(l_i^*\). The stock has a range of \(r\) acres. The degree to which the stock is a common pool resource depends on the lease structure over the stock’s range. The portion of the range leased by club \(i\) is \(l_i^* / r\). Through the portion of the range leased, lease size has two countervailing effects on the quantity of deer harvested: (1) increased control over the stock and (2) increased the access to the stock. Increased control over the stock implies they are better able to exclude others from using the stock. This affects the club’s level of “patience” or willingness to pass up younger lower quality deer. Alternatively, increased access to the stock implies harvesting will require less effort. The total effect on the quantity harvested depends on which effect dominates. Denoting stock \(x\) and effort \(f\), we assume the harvest of club \(i\) is given by the production function,

\[
h_i(f_i, r, l_i^*, x).
\]

where \(h_f \geq 0\), \(h_{ff} \leq 0\), \(h_x \geq 0\), and \(h_{xx} \leq 0\). We assume harvest is concave in effort and stock to reflect the standard yield-effort and maximum sustainable yield curves.

\(^{18}\) When price are endogenous, landowners maintain the incentive to manage for quality and invest in habitat improvements. In the next section, the panel data show habitat improvements are not made and leases do not change ownership over the course of the panel.
Now consider the process that governs the stock. Environmental conditions affecting the growth of the deer population are described by a set of ecological variables, $E$. The stock follows some growth function $g(x,E)$. The population dynamics are,

$$\dot{x} = g(x,E) - \sum_{i=1}^{n} h_i \left( f_i, r, l_i^*, x \right)$$

(2)

where $n$ is the number of clubs harvesting the stock. In the steady state, where $\dot{x} = 0$, we can rewrite (2),

$$g(x,E) = \sum_{i=1}^{n} h_i \left( f_i, r, l_i^*, x \right).$$

(3)

From (3), we can implicitly solve for the steady state stock,

$$\bar{x} \left( f_1, \ldots, f_n, l_1^*, \ldots, l_n^*, r, E \right).$$

(4)

Substituting (4) into (2), we have steady state harvest in terms of effort, lease size, and ecological variables,

$$\bar{h} \left( f_1, \ldots, f_n, l_1^*, \ldots, l_n^*, r, E \right).$$

(5)

3.2.2 Quality

The harvest function defined in (1) and (5) map effort, lease sizes, range size, and stock to quantity of deer harvested. It does not quantify quality. We assume hunting clubs value the average quality of deer harvested. In order to quantify average quality of deer harvested, an additional production function is necessary. We assume there are two determinants of average quality of deer harvested — the portion of the range leased and harvest rate. The portion of the range leased determines the club’s patience or willingness to pass up younger lower quality deer. The average quality of deer harvested positively depends on club patience. The more patient a
club, the more hunting opportunities of younger lower quality deer they pass up in favor of higher quality deer. Additionally, the average quality of deer harvested negatively depends on the harvest rate, or the harvest relative to stock. Due to natural deaths and hunting activity, only a small portion of deer will reach a high quality. The majority of deer have low or average quality. The higher the harvest rate, the more low and average quality deer harvested, and the lower the average quality of deer harvested. We assume a production function exist that maps the determinants of club patience and harvest rate to an average quality of deer harvested,

$$q_i(x, l_i^*, r, h_i).$$

(6)

Substituting (4) and (5) into (6), we get our quality in terms of lease size, effort, and ecological variables,

$$\bar{q}_i(f_1, \ldots, f_n, l_i^*, \ldots, l_n^*, r, E)$$

or

$$\bar{q}_i(\bar{x}(f_1, \ldots, f_n, l_i^*, \ldots, l_n^*, r, E), l_i^*, r, \bar{h}_i(f_1, \ldots, f_n, l_i^*, \ldots, l_n^*, r, E)).$$

(7)

3.2.3 The Club’s Problem

Hunting clubs derive utility from the average quality of deer and quantity of deer harvested. Each club has a planner that maximizes the following utility function,

$$U_i(q_i, h_i).$$

(8)

where $U_q > 0$, $U_{qq} \leq 0$, $U_h > 0$, $U_{hh} \leq 0$. Substituting (5) and (7) into (8), a club’s utility maximization problem can be written as,

$$\max_{f_i} U_i(\bar{q}_i(\bar{x}, l_i^*, \bar{h}_i), \bar{h}_i).$$
The first order condition is,

\[
\frac{\partial U_i}{\partial f_i} = \frac{\partial U_i}{\partial q_i} \frac{\partial q_i}{\partial f_i} + \frac{\partial U_i}{\partial q_i} \frac{\partial h_i}{\partial f_i} \left( \frac{\partial h_i}{\partial f_i} + \frac{\partial h_i}{\partial f_i} \right) + \frac{\partial U_i}{\partial h_i} \left( \frac{\partial h_i}{\partial f_i} + \frac{\partial h_i}{\partial f_i} \right) = 0. \tag{9}
\]

The first term in (9) is the disutility from a decreased average quality as a result of a smaller stock. As effort increases, stock decreases, and quality suffers. The second term is the marginal utility associated with a change in average quality from an increased harvest. The sign of this term depends on where we are on the yield-effort curve. If \( h_f + h_x \bar{x}_f > 0 \), this term is negative. As effort increases, harvest increases, decreasing average quality. This will hold if harvest and effort are below the maximum sustainable yield levels. Once the maximum sustainable yield is reached, any increase in effort reduces equilibrium harvest. The last term is the marginal utility of harvest. Now, if \( h_f + h_x \bar{x}_f > 0 \), this term is positive. Rearranging (9) illustrates a club will choose effort such that the marginal utility from additional effort is equal to the marginal disutility of a lower average quality,

\[
\frac{\partial U_i}{\partial h_i} \left( \frac{\partial h_i}{\partial f_i} + \frac{\partial h_i}{\partial f_i} \right) = -\frac{\partial U_i}{\partial q_i} \frac{\partial q_i}{\partial f_i} - \frac{\partial U_i}{\partial h_i} \frac{\partial h_i}{\partial f_i} \left( \frac{\partial h_i}{\partial f_i} + \frac{\partial h_i}{\partial f_i} \right). \tag{10}
\]

The right-hand side of (10) is the internalized user cost of effort. If more than one club is harvesting the stock, one club’s effort will create negative externalities for the other clubs. Unless the clubs are cooperating, these externalities are not internalized and will not arise within the club’s first order condition. If we consider the social planners problem, the first order condition for club \( i \)’s effort will include the externalities imposed on all other clubs harvesting the stock. The social planner first order condition for club \( i \)’s effort is,
\[
\frac{\partial U_i}{\partial f_i} = \frac{\partial U_j}{\partial U_i} \frac{\partial U_j}{\partial q_i} \frac{\partial q_j}{\partial f_i} + \frac{\partial U_j}{\partial U_i} \frac{\partial q_j}{\partial h_i} \frac{\partial h_j}{\partial f_i} + \frac{\partial U_j}{\partial U_i} \frac{\partial h_j}{\partial f_i} \frac{\partial h_j}{\partial f_i} \frac{\partial U_i}{\partial q_j} \frac{\partial q_j}{\partial h_j} \frac{\partial h_j}{\partial f_j} \frac{\partial U_i}{\partial q_j} \frac{\partial q_j}{\partial x} \frac{\partial x}{\partial f_j} + \frac{\partial U_j}{\partial U_i} \frac{\partial q_j}{\partial h_j} \frac{\partial h_j}{\partial x} \frac{\partial x}{\partial f_j} \frac{\partial U_i}{\partial q_j} \frac{\partial q_j}{\partial x} \frac{\partial x}{\partial f_j} \frac{\partial U_i}{\partial q_j} \frac{\partial q_j}{\partial x} \frac{\partial x}{\partial f_j} \]

\sum_{j=1}^{n-1} \left[ \frac{\partial U_i}{\partial U_j} \frac{\partial U_j}{\partial q_j} \frac{\partial q_j}{\partial x} \frac{\partial x}{\partial f_j} + \frac{\partial U_j}{\partial U_i} \frac{\partial q_j}{\partial h_j} \frac{\partial h_j}{\partial x} \frac{\partial x}{\partial f_j} + \frac{\partial U_j}{\partial U_i} \frac{\partial h_j}{\partial x} \frac{\partial x}{\partial f_j} \frac{\partial U_i}{\partial q_j} \frac{\partial q_j}{\partial x} \frac{\partial x}{\partial f_j} \frac{\partial U_i}{\partial q_j} \frac{\partial q_j}{\partial x} \frac{\partial x}{\partial f_j} \right] = 0

for all \( j \neq i \). The externalities from club \( i \)’s effort imposed on all other clubs are contained within the summation operator. However, given transaction costs, it is unlikely clubs cooperate and consider the externalities of their effort.

Continuing with the individual club’s problem, the optimal level of effort can be implicitly solved for using (9),

\[
f_i^* \left(l_i^*, \ldots, l_n^*, r, E\right).
\]

Substituting (11) for all \( n \) clubs into (4) and (2), we get the optimal steady state stock and harvest rate,

\[
x^* \left(l_i^*, \ldots, l_n^*, r, E\right)
\]

and

\[
h_i^* \left(l_i^*, \ldots, l_n^*, r, E\right).
\]

Finally, substituting (12) and (13) into (6), we get the optimal quality,

\[
q^* \left(l_i^*, \ldots, l_n^*, r, E\right) \text{ or } q \left(x^* \left(l_i^*, \ldots, l_n^*, r, E\right), l^*, r, h^* \left(l_i^*, \ldots, l_n^*, r, E\right)\right). \tag{14}
\]

### 3.2.4 Effect of Lease Size

A change in lease size has three effects on quality. The first is the direct effect through a club’s patience or willingness to pass up hunting opportunities. The second and third are through the indirect effects of lease size on the stock and harvest rate. The comparative static can be written as,
\[
\frac{dq^*_{i}}{dl^*_{i}} = \frac{\partial q_{i}^*}{\partial x} \frac{dx^*}{dl^*_{i}} + \frac{\partial q_{i}^*}{\partial l^*_{i}} + \frac{\partial q_{i}^*}{\partial h^*_{i}} \frac{dh^*_{i}}{dl^*_{i}} \\
\text{or} \\
\frac{dq^*_{i}}{dl^*_{i}} = \frac{\partial q_{i}^*}{\partial x} \left( \frac{\partial f_{i}^*}{\partial l^*_{i}} + \frac{\partial x}{\partial l^*_{i}} \right) + \frac{\partial q_{i}^*}{\partial l^*_{i}} \left( \frac{\partial h_{i}^*}{\partial f_{i}^*} \frac{\partial f_{i}^*}{\partial l^*_{i}} + \frac{\partial x}{\partial l^*_{i}} \right) + \frac{\partial q_{i}^*}{\partial h^*_{i}} \left( \frac{\partial h_{i}^*}{\partial f_{i}^*} \frac{\partial f_{i}^*}{\partial l^*_{i}} + \frac{\partial x}{\partial l^*_{i}} \right).
\]

(15)

Based on the assumption that average quality is increasing in club patience and willingness to pass up younger lower quality deer, we assume the direct effect is positive. Based on the assumption that the average quality is decreasing in harvest rate, we assume \( \partial q_{i}^* / \partial x > 0 \) and \( \partial q_{i}^* / \partial h > 0 \). We also assume \( \partial h_{i}^* / \partial f_{i}^* > 0 \) and \( \partial h_{i}^* / \partial l^*_{i} > 0 \). The sign of the remaining components of the indirect stock and harvest effects are ambiguous. The sign of the indirect stock and harvest effects are characterized by the following sets of inequalities,

\[
\text{indirect stock effect} \begin{cases} 
\geq 0 & \text{if} \quad \frac{\partial x}{\partial f_{i}^*} \frac{df_{i}^*}{dl^*_{i}} + \frac{\partial x}{\partial l^*_{i}} \geq 0 \\
< 0 & \text{if} \quad \frac{\partial x}{\partial f_{i}^*} \frac{df_{i}^*}{dl^*_{i}} + \frac{\partial x}{\partial l^*_{i}} < 0 
\end{cases}
\]

and

\[
\text{indirect harvest effect} \begin{cases} 
\geq 0 & \text{if} \quad \frac{\partial h_{i}^*}{\partial f_{i}^*} \frac{df_{i}^*}{dl^*_{i}} + \frac{\partial h_{i}^*}{\partial l^*_{i}} \left( \frac{\partial x}{\partial f_{i}^*} \frac{df_{i}^*}{dl^*_{i}} + \frac{\partial x}{\partial l^*_{i}} \right) \leq 0 \\
< 0 & \text{if} \quad \frac{\partial h_{i}^*}{\partial f_{i}^*} \frac{df_{i}^*}{dl^*_{i}} + \frac{\partial h_{i}^*}{\partial l^*_{i}} \left( \frac{\partial x}{\partial f_{i}^*} \frac{df_{i}^*}{dl^*_{i}} + \frac{\partial x}{\partial l^*_{i}} \right) > 0.
\end{cases}
\]

The details of signing \( \partial x / \partial f_{i}^* \), \( \partial x / \partial l^*_{i} \), and \( \partial f_{i}^* / \partial l^*_{i} \) are given in appendix 3.1. In short, if \( dx^* / dl^*_{i} \geq 0 \), the indirect stock effect is positive and if \( dh^*_{i} / dl^*_{i} > 0 \), the indirect harvest effect is negative. Assuming the indirect effects are not both positive, signing (15) depends on the
relationship between the magnitudes of the direct and indirect effects. In the following subsections we estimate the direct and indirect effects and calculate the total effect of (15).

Recall the effect of lease size on harvest is determined by the two countervailing effects: (1) the decreased harvest from increased patience and (2) the increased harvest from increased access to the stock. The indirect harvest effect accounts for the relationship between lease size, the quantity of deer harvested, and the average quality of deer harvested. While the sign of \( \frac{dh_i^*}{dl_i^*} \) will determine which effect dominates, estimating harvest per acre will provide a testable hypothesis for the first effect. If harvest per acre is decreasing with lease size, clubs may be more patient and willing to forgo harvesting younger lower quality deer. Whether this behavior actually results in a higher average quality of deer harvested depends on the sign of the estimated direct effect.

3.3 Data

The data used was provided by the Mississippi Department of Wildlife and Fisheries (MDWF) and Strickland and Demarais (2008). The data is a time-series cross-section from 1991 to 1994. It includes information for the quality and quantity of male deer harvested by a number of hunting clubs that were participating in MDWF Deer Management Assistance Program (DMAP). The data also include the sizes of the hunting club leases and various lease specific ecological variables. The data includes 197 clubs. Each hunting season represents one observation per club. The panel is unbalanced in that it does not contain four hunting seasons for all clubs. There is a minimum of two observations per club. There are 768 observations in total.

To determine quality, each observation has antler measurements including the spread, length, circumference, and number of points. These measurements are used to create an index to
assess overall antler size. The index is calculated as the sum of the spread, length, circumference, and number of points. Strickland and Demarais (2000) illustrate the index correlates very well with gross Boone and Crockett scores.\(^\text{19}\) The Boone and Crockett (BC) score is widely accepted as a measure of antler quality in the hunting community. Additionally, this index has been used to estimate gross Boone and Crockett scores in the ecology literature (Strickland and Demarais, 2008). However, the estimation was specifically for certain age groups. As our data includes age groups not included in their analysis, we use the antler index as our quality measure.

Information for the range size of each deer stock was not available. However, range size is largely determined by habitat quality which we control for using the ecological variables. The quality of deer depends heavily on quality of their habitat. The ecologic information consists of land composition measures for vegetation, land-use and cover, and landscape structure. This information was gathered from the Gap Analysis Program (Vilella et al., 2003). We use 10 land composition measures and a Shannon’s diversity index. The ecological variables used are shown in table 3.1. Shannon’s diversity index measures the diversity of land composition within each lease. It also captures the abundance and continuity of land compositions.

We aggregate the 10 land composition variables into three subcategories — pine forest, hardwood forest, and food sources. The pine forest variable is the sum of low-density, medium density, and high-density pine forest land compositions. The hardwood forest variable is the sum of bottomland hardwood, high-density hardwood, and medium-density hardwood land compositions. Both the pine and hardwood forest variables provide a measure of the cover or

\(^{19}\) The index has a Pearson correlation coefficient, \(r=0.97\) and \(P < 0.001\) (Strickland and Demarais, 2000).
shelter available to the deer. The food variable is the sum of land composition in agriculture, pasture, shrub land, or water.

<table>
<thead>
<tr>
<th>Table 3.1 Land Composition Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of land in agricultural</td>
</tr>
<tr>
<td>Percentage of land in bottom-land hardwood forest</td>
</tr>
<tr>
<td>Percentage of land in high-density hardwood forest</td>
</tr>
<tr>
<td>Percentage of land in medium-density hardwood forest</td>
</tr>
<tr>
<td>Percentage of land in high-density pine forest</td>
</tr>
<tr>
<td>Percentage of land in medium-density pine forest</td>
</tr>
<tr>
<td>Percentage of land in low-density pine forest</td>
</tr>
<tr>
<td>Percentage of land in pasture land</td>
</tr>
<tr>
<td>Percentage of land in shrub habitat</td>
</tr>
<tr>
<td>Percentage of land in water</td>
</tr>
</tbody>
</table>

Finally, our data includes the number of female deer harvested by each club. During the 1991-1994 seasons, only clubs participating in the DMAP program were able to harvest female deer. The number of female deer each club was allowed to harvest was determined by a biologist. The biologists based their decisions on herd density, habitat quality, and levels of depredation. We include female deer harvested in our empirical analysis to capture this information. The summary statistics are shown in table 3.2.
Table 3.2 Summary Statistics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lease size (acres)</td>
<td>3736.5</td>
<td>2799.19</td>
<td>432.00</td>
<td>15750.00</td>
</tr>
<tr>
<td>Number of male deer harvested</td>
<td>25.11</td>
<td>15.25</td>
<td>2</td>
<td>101</td>
</tr>
<tr>
<td>Number of female deer harvested</td>
<td>33.60</td>
<td>26.63</td>
<td>0</td>
<td>215</td>
</tr>
<tr>
<td>Antler index</td>
<td>48.95</td>
<td>10.55</td>
<td>23.47</td>
<td>80.03</td>
</tr>
<tr>
<td>Shannon’s diversity index</td>
<td>1.47</td>
<td>0.46</td>
<td>0.10</td>
<td>2.28</td>
</tr>
<tr>
<td>Pine Forest</td>
<td>15.05</td>
<td>16.86</td>
<td>0</td>
<td>87.12</td>
</tr>
<tr>
<td>% of land in high-density pine forest</td>
<td>4.62</td>
<td>8.08</td>
<td>0.00</td>
<td>66.11</td>
</tr>
<tr>
<td>% of land in medium-density pine forest</td>
<td>8.43</td>
<td>8.42</td>
<td>0.00</td>
<td>34.74</td>
</tr>
<tr>
<td>% of land in low-density pine forest</td>
<td>1.98</td>
<td>3.46</td>
<td>0.00</td>
<td>15.98</td>
</tr>
<tr>
<td>Hardwood Forest</td>
<td>52.72</td>
<td>23.12</td>
<td>3.20</td>
<td>98.22</td>
</tr>
<tr>
<td>% of land in bottom-land hardwood forest</td>
<td>24.23</td>
<td>28.79</td>
<td>0.00</td>
<td>98.22</td>
</tr>
<tr>
<td>% of land in high-density hardwood forest</td>
<td>1.61</td>
<td>2.44</td>
<td>0.00</td>
<td>14.26</td>
</tr>
<tr>
<td>% of land in medium-density hardwood forest</td>
<td>26.88</td>
<td>25.29</td>
<td>0.00</td>
<td>85.17</td>
</tr>
<tr>
<td>Food Sources</td>
<td>21.65</td>
<td>11.89</td>
<td>0.90</td>
<td>77.35</td>
</tr>
<tr>
<td>% of land in agricultural</td>
<td>4.75</td>
<td>8.46</td>
<td>0.00</td>
<td>70.25</td>
</tr>
<tr>
<td>% of land in pasture land</td>
<td>10.95</td>
<td>9.74</td>
<td>0.00</td>
<td>46.01</td>
</tr>
<tr>
<td>% of land in shrub habitat</td>
<td>0.77</td>
<td>1.80</td>
<td>0.00</td>
<td>13.32</td>
</tr>
<tr>
<td>% of land in water</td>
<td>5.17</td>
<td>7.96</td>
<td>0.012</td>
<td>38.43</td>
</tr>
</tbody>
</table>

3.4 Empirical Strategy

The goal of this chapter is to estimate the effect of lease size on big game quality. In section two we outlined a theoretical framework developing that relationship. Our model suggests there are direct and indirect effects. The indirect effects stem from lease size affecting harvest rates and stock size. Equation (14) shows quality is determined by lease size, harvest, and stock, where both harvest and stock are determined by lease size and ecological variables. Estimating the separate indirect harvest and stock effects requires harvest and stock data. We have harvest data, but stock data is not available. We are able to estimate the indirect harvest effect and a
combined direct and indirect stock effect. The combined effect is the sum of the direct effect and the indirect stock effect.

Recall the composition of the indirect effects in (15). The indirect harvest effect is the product of the effect of harvest on quality and the effect of lease size on harvest,

\[
\frac{dq^*}{dh^*} \frac{dh^*}{d\ell^*}.
\]

(16)

We are able to estimate both the effect of lease size on harvest and the effect of harvest on quality. To find the effect of lease size on harvest, we estimate (13). We estimate (14) for the combined direct and indirect effect of lease size on quality and the effect of harvest on quality. Both regressions include various ecological variables. The ecological variables included are the pine forest, hardwood forest, and food source land composition variables, and Shannon’s diversity index.

However, there exists the risk of lease size endogeneity. If the quality of deer in an area affects leasing behavior, lease size is endogenous in the quality regression. Similarly, if the number of deer harvested affects leasing behavior, lease size is endogenous in the harvest regression. We use an instrumental variable approach to control for this endogeneity.

We instrument lease size using 1997 Census of Agriculture data on the average farm size for each county in which the hunting clubs are located. It is not difficult to imagine that the majority of hunting leases are found on some type of farmland. For legal and ecological reasons, hunting takes place in rural areas. Rural areas usually include lands used for various farming activities. The census defines a farm as any place producing $1000 or more of agricultural products during the census year. This also includes lands set aside for the Conservation Reserve
Program and other lands not directly under use, provided they were part of the farm’s total operation. The census also includes hunting in their definition of agricultural activity. Lands that are used solely for hunting activity are considered farmland.\textsuperscript{20}

We assume as the average farm size for a county increases, the average size of the hunting lease within that county also increases. We cannot be certain landowners do not cooperate, leading to hunting leases crossing multiple properties. However, transaction costs suggest the occurrence of hunting leases spanning multiple properties is limited. Some states have block management programs encouraging private landowners to cooperate. To my knowledge Mississippi does not have such a program.

Additionally, harvest is endogenous in the quality regression. As a club increases the average quality of deer harvested, they are also decreasing their harvest rate. We instrument harvest in the quality regression using a lagged value. Using this approach, we lose an observation within each group. However, considering the majority of our variation is between groups, this should not be an issue. The alternative would be instrumenting harvest using predicted values from the harvest regression. The covariates used in the harvest regression are also used in the quality regression. To identify our second regression, an additional variable that only affects harvest and not quality would need to be included in the harvest regression. As no such variables are readily available, we use a lagged harvest value. Assuming the stock is in a steady state, the harvest should not very considerably across years.

To summarize, we estimate the harvest regression, or equation (13), using lease size, our set of ecological variables, and the number of female deer harvested. This yields the effect of

\footnotesize{\textsuperscript{20}http://www.agcensus.usda.gov/Publications/1997/Vol_1_Chapter_1_U._S._National_Level_Data/us-51/us1gexp.pdf}
lease size on harvest, or the second term in (16). Using the same covariates with the addition of a lagged value of harvest, we estimate the quality regression, or equation (14). This yields two important results. First, the coefficient for harvest represents our estimated effect of harvest on quality, or the first term in (16). Using this and our coefficient for lease size from the harvest regression, we can calculate our estimate for the indirect harvest effect of lease size on quality. Second, the coefficient for lease size in the quality regression represents the combined direct and indirect effect. This is the sum of the direct effect and the indirect stock effect. Recall we cannot separate the indirect stock effect because we lack stock data.

3.4.1 Estimation and testing

A random effects model is used, as the bulk of our data’s variation is between hunting clubs.\(^{21}\) The harvest and quality random effects estimators are estimated using both generalized lease squares and feasible generalized two-stage least squares (Balestra and Varadharajan-Krishnakumar, 1987). See appendix 3.2 for the derivation of the G2SLS estimator. The logs of male and female deer harvested, lease size, and farm size are used in each regressions. The coefficients for these variables are elasticities. They will be converted into marginal effects to calculate the comparative static in (15).

We test for underidentification and weak instruments. Testing the rank condition is usually done using canonical correlations or a Cragg-Donald Wald statistic (Anderson, 1951; Cragg and Donald, 1993). These statistics are only valid if the errors are independently and identically distributed. Given the nature of our data, this assumption may not hold. One club’s

\(^{21}\) A Breusch and Pagan Lagrangian Multiplier test for the null hypothesis of no cross club variation is rejected at the 1 percent level for both regressions. Including club specific fixed effects is difficult to justify as it would result in the loss of 196 degrees of freedom.
harvest may affect another club’s. Kleibergen and Paap (2006) propose a number of alternative robust test statistics. We use Kleibergen and Paap test statistics to evaluate our instruments.

How do we compare the G2SLS and GLS estimates? Given a panel and the presence of heteroskedasticity, the Durbin-Wu-Hausman test of exogenous regressors is not valid. If additional excluded instruments were available, the exogeneity of lease size could be tested using a Hansen–Sargan–Basman GMM difference test, or $C$ test (Baum et al., 2003; Hansen, 1982; Sargan, 1958; Basmann, 1960). Unfortunately, additional excluded instruments are not available and we cannot formally test between the G2SLS and GLS estimates.

However, an argument can be made for considering the G2SLS estimates over the GLS. Hunters often engage in an activity referred to as scouting. Scouting consists of visiting a potential hunting location to gather information to make an informed decision as to whether or not to hunt the area. The number and quality of game animals in the area is valuable information and will certainly influence the hunting decision. Hunters or hunting clubs are not likely to lease an area with no a priori knowledge of the number and quality of game in an area. Thus, leasing behavior is most likely not independent of harvest and quality and the G2SLS estimates should be considered over the GLS. The GLS results are considered for comparison.

### 3.5 Results

Recall our interest in the affect of lease size on harvest per acre. Lease size determines the likelihood of experiencing negative externalities. This manifests itself in harvest per acre. With a decreased likelihood of externalities, the club becomes more patient and willing to pass up younger lower quality deer because they are more likely to reap the reward of doing so. Reward
being the harvest of a bigger antlered deer in the future. A decreasing harvest per acre is suggestive of this type of selective harvesting behavior.

The estimated harvest equation takes the form,

\[
\text{harvest} = \beta_0 \times \text{lease\_size}^{\beta_1} \times \exp[\beta_2 \times \text{covariates\_logged}] \times \exp[\beta_3 \times \text{covariates\_levels}] 
\]  

where \( \beta_0 \) is an intercept, \( \beta_1 \) is the coefficient for lease size, covariates\_logged is a vector of logged covariates, covariates\_levels is a vector of covariates in levels, and \( \beta_2 \) and \( \beta_3 \) are vectors of their corresponding coefficients. The lease size coefficient is the lease size elasticity of harvest. Given lease size is measured in acres and assuming (17) holds, dividing (17) by lease size yields harvest per acre,

\[
\frac{\text{harvest}}{\text{lease\_size}} = \beta_0 \times \text{lease\_size}^{\beta_1 - 1} \times \exp[\beta_2 \times \text{covariates\_logged}] \times \exp[\beta_3 \times \text{covariates\_levels}] 
\]

A coefficient for lease size such that \( \beta_1 < 1 \) suggests harvest per acre is decreasing with lease size. If the coefficient is less than zero, harvest per acre is decreasing with lease size at an increasing rate. A coefficient equal to one will result in a constant harvest per acre. Lastly, harvest per acre will increase with lease size given a coefficient greater than one.

Consider the harvest regressions in table 3.3. The lease size coefficient for the G2SLS estimator is 0.2013. However, with a p-value of 0.501, it is not significantly different from zero. The GLS coefficients are found in the second column. The coefficient for lease size is 0.3067. It is significantly different from zero at the 1 percent level. Taking the coefficients at their value, they suggest harvest per acre decreases with lease size. Considering the G2SLS estimator, a one percent increase in lease size will result in a 0.7987 percent decrease in harvest per acre. Considering the GLS estimator, a one percent increase in lease size would result in 0.6933
percent decrease in harvest per acre. Treating the coefficient as zero, the lease size elasticity of harvest is zero, and a one percent increase in lease size will result in a decrease in harvest per acre of one percent. Recall the total effect of lease size on harvest is determined by the two countervailing effects: (1) the decreased harvest from increased patience and (2) the increased harvest from increased access to the stock. In either case, the results suggest the reduced harvest from improved patience offsets the increased harvest from better access.

<table>
<thead>
<tr>
<th>Variable</th>
<th>G2SLS</th>
<th>GLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log of lease size</td>
<td>0.2013</td>
<td>0.3067</td>
</tr>
<tr>
<td></td>
<td>(0.2990)</td>
<td>(0.0503)**</td>
</tr>
<tr>
<td>% of land in pine forest</td>
<td>0.0045</td>
<td>0.0057</td>
</tr>
<tr>
<td></td>
<td>(0.0064)</td>
<td>(0.0056)</td>
</tr>
<tr>
<td>% of land in hardwood forest</td>
<td>0.0091</td>
<td>0.0115</td>
</tr>
<tr>
<td></td>
<td>(0.0087)</td>
<td>(0.0056)**</td>
</tr>
<tr>
<td>% of land in food sources</td>
<td>0.0011</td>
<td>0.0021</td>
</tr>
<tr>
<td></td>
<td>(0.0066)</td>
<td>(0.0058)</td>
</tr>
<tr>
<td>Shannon’s diversity index</td>
<td>0.3561</td>
<td>0.3731</td>
</tr>
<tr>
<td></td>
<td>(0.1275)**</td>
<td>(0.1037)**</td>
</tr>
<tr>
<td>Log of female deer harvested</td>
<td>0.2001</td>
<td>0.1500</td>
</tr>
<tr>
<td></td>
<td>(0.1501)</td>
<td>(0.0560)**</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.3157</td>
<td>-1.1836</td>
</tr>
<tr>
<td></td>
<td>(2.5322)</td>
<td>(0.7187)**</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
* significant at 15%; ** significant at 10%; *** significant at 5%

The results for the G2SLS reduced form (first stage) regressions are presented in table 3.4. The coefficient for average farm size is positive and significantly different from zero at the 1 percent level. From these results, we can surmise average farm size to be a relevant instrument for lease size. This suggests average farm size is correlated with lease size. The partial R-Squared suggests 3.63 percent of the variation in lease size can be explained by farm size. The Kleibergen-Paap test statistics are reported in table 3.6. Considering the LM statistic, the $X'Z$
matrix has full rank and our equation is not underidentified. The F statistic suggests any size distortions of the instrumental variable estimates are less than 10 percent of their maximum values.\footnote{See Stock and Yogo (2005) for critical values.}

<table>
<thead>
<tr>
<th>Variable</th>
<th>Harvest</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of land in pine forest</td>
<td>-0.0072</td>
<td>-0.0078</td>
</tr>
<tr>
<td></td>
<td>(0.0035) ***</td>
<td>(0.0040) ***</td>
</tr>
<tr>
<td>% of land in hardwood forest</td>
<td>-0.0220</td>
<td>-0.0226</td>
</tr>
<tr>
<td></td>
<td>(0.0034) ***</td>
<td>(0.0040) ***</td>
</tr>
<tr>
<td>% of land in food sources</td>
<td>-0.0094</td>
<td>-0.0096</td>
</tr>
<tr>
<td></td>
<td>(0.0037) ***</td>
<td>(0.0043) ***</td>
</tr>
<tr>
<td>Shannon’s diversity index</td>
<td>0.0129</td>
<td>-0.0192</td>
</tr>
<tr>
<td></td>
<td>(0.0807)</td>
<td>(0.0931)</td>
</tr>
<tr>
<td>Log of lagged male deer</td>
<td>-</td>
<td>0.0973</td>
</tr>
<tr>
<td>harvested</td>
<td></td>
<td>(0.0241) ***</td>
</tr>
<tr>
<td>Log of female deer harvested</td>
<td>0.4774</td>
<td>0.4505</td>
</tr>
<tr>
<td></td>
<td>(0.0300) ***</td>
<td>(0.0352) ***</td>
</tr>
<tr>
<td>Log of average county farm size</td>
<td>0.2857</td>
<td>0.2759</td>
</tr>
<tr>
<td></td>
<td>(0.0534) ***</td>
<td>(0.0616) ***</td>
</tr>
<tr>
<td>Constant</td>
<td>6.1720</td>
<td>6.1098</td>
</tr>
<tr>
<td></td>
<td>(0.5331) ***</td>
<td>(0.6133) ***</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
* significant at 15%; ** significant at 10%; *** significant at 5%

Moving to the quality regressions, consider table 3.5. The coefficients for lease size are 0.2605 and 0.0279 for the G2SLS and GLS. With a p-value of 0.057, the G2SLS coefficient is significantly different from zero. The GLS coefficient is much smaller and less significant with a p-value of 0.104. Both estimates suggest the average quality of deer harvested increase with lease size. Also, note the coefficients for harvest are negative and significantly different from zero for both estimators.
In the reduced form regression, the coefficient for our instrument, average farm size, is positive and significantly different from zero. The partial R-Squared of suggests only 3.48 percent of variation in lease size is explained by our excluded instrument. From the Kleibergen-Paap LM statistic, we can reject the null of underidentification. However, the Kleibergen-Paap F statistic suggests our coefficients may be slightly distorted. The F statistic is 15.24. The critical value for a distortion less than 10 percent of the estimate’s maximum value is 16.38.

<table>
<thead>
<tr>
<th>Variable</th>
<th>G2SLS</th>
<th>GLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log of lease size</td>
<td>0.2605</td>
<td>0.0279</td>
</tr>
<tr>
<td></td>
<td>(0.1366)**</td>
<td>(0.0172)*</td>
</tr>
<tr>
<td>% of land in pine forest</td>
<td>-0.0002</td>
<td>-0.0029</td>
</tr>
<tr>
<td></td>
<td>(0.0029)</td>
<td>(0.0021)</td>
</tr>
<tr>
<td>% of land in hardwood forest</td>
<td>0.0057</td>
<td>0.0006</td>
</tr>
<tr>
<td></td>
<td>(0.0040)*</td>
<td>(0.0020)</td>
</tr>
<tr>
<td>% of land in food sources</td>
<td>0.0058</td>
<td>0.0038</td>
</tr>
<tr>
<td></td>
<td>(0.0029)***</td>
<td>(0.0023)*</td>
</tr>
<tr>
<td>Shannon’s diversity index</td>
<td>-0.0890</td>
<td>-0.1236</td>
</tr>
<tr>
<td></td>
<td>(0.0581)*</td>
<td>(0.0378)***</td>
</tr>
<tr>
<td>Log of lagged male deer harvested</td>
<td>-0.0457</td>
<td>-0.0465</td>
</tr>
<tr>
<td></td>
<td>(0.0200)***</td>
<td>(0.0156)***</td>
</tr>
<tr>
<td>Log of female deer harvested</td>
<td>-0.0604</td>
<td>0.0502</td>
</tr>
<tr>
<td></td>
<td>(0.0649)</td>
<td>(0.0216)***</td>
</tr>
<tr>
<td>Constant</td>
<td>1.8443</td>
<td>3.7485</td>
</tr>
<tr>
<td></td>
<td>(1.1360)*</td>
<td>(0.2530)***</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
* significant at 15%; ** significant at 10%; *** significant at 5%

<table>
<thead>
<tr>
<th>Table 3.6 Kleibergen-Paap Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Kleibergen-Paap LM statistic</td>
</tr>
<tr>
<td>P-value</td>
</tr>
<tr>
<td>Kleibergen-Paap F statistic</td>
</tr>
</tbody>
</table>

Critical values for size distortion less than:

| 10% maximal IV size | 16.38 | 16.38 |
| 15% maximal IV size | 8.96  | 8.96  |
| 20% maximal IV size | 6.66  | 6.66  |
3.5.1 The Effects

Using the results from both regressions, we can calculate the total effect of lease size. However, our variables of interest are in logs, so the coefficients are elasticities. Before calculating the total effect, the elasticities must be converted into marginal effects. The marginal effect is simply the product of the elasticity and its ratio of variables in levels. For example, the marginal effect of lease size on harvest is,

$$\beta_1 \frac{\text{harvest}}{\text{lease}_\text{size}}.$$

The relevant marginal effects are shown in table 3.7. The total effect is the sum of the combined effect, which corresponds to the marginal effect of lease size from the quality regression and the indirect harvest effect, which we will now calculate. Recall the indirect harvest effect in (16). It is the product of the marginal effect of lease size on harvest and the marginal effect of harvest on quality. Considering the harvest G2SLS marginal effects, the indirect harvest effect is -0.000250. This suggests an increase in lease size of 1000 acres will result in a decrease in the antler index of 0.25 units. If we treat the harvest G2SLS lease size coefficient as zero, the indirect effect is zero. Using the GLS estimates, we have an indirect harvest effect of -0.000388. This suggests a 1000 acre increase in lease size would result in the antler index decreasing 0.388 units.

<table>
<thead>
<tr>
<th>Table 3.7 Marginal Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Lease size</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Harvest</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Standard errors in parentheses
* significant at 15%; ** significant at 10%; *** significant at 5%
Table 3.8 presents the combination, indirect harvest, and total effects of lease size. Using the marginal effects from the G2SLS estimators, and assuming the lease size coefficient from the harvest regression is really 0.2013, not zero, we have a total effect of 0.005258. This suggests a 1000 acre increase in lease size will result in the antler index increasing 5.26 units. Treating the lease size coefficient from the harvest regression as zero, the total effect is simply the combined marginal lease effect from the quality regression. Using the GLS estimates, the total effect is 0.000202. A 1000 acre increase in lease size will result in the antler index increasing by 0.2 units.

<table>
<thead>
<tr>
<th>Effect</th>
<th>G2SLS</th>
<th>GLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect Harvest Effect</td>
<td>-0.000250*</td>
<td>-0.000388***</td>
</tr>
<tr>
<td></td>
<td>(0.000153)</td>
<td>(0.000127)</td>
</tr>
<tr>
<td>Combined direct effect and indirect stock effect.</td>
<td>0.005508***</td>
<td>0.000590*</td>
</tr>
<tr>
<td></td>
<td>(0.002889)</td>
<td>(0.000363)</td>
</tr>
<tr>
<td>Total effect</td>
<td>0.005258***</td>
<td>0.000202</td>
</tr>
<tr>
<td></td>
<td>(0.001368)</td>
<td>(0.000174)</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
* significant at 15%; ** significant at 10%; *** significant at 5%

To illustrate the impact of these results, we estimate the effects of a simulated increase in lease size. The average lease size is 3736.5 acres. There are 121 hunting clubs with smaller than average lease sizes. Using the G2SLS estimates, a simulated increase in lease size to the average decreases the average harvest per acre 38.25 percent, from 8.23 to 5.83, and increases the average antler index 4.50 percent, from 49.09 to 53.52. If we treat the harvest effect as zero, the increase in antler index becomes 4.75 percent.

In summary, our results suggest club harvest per acre is decreasing with lease size and the total effect of lease size on antler quality, given by equation (15), is indeed positive. Combined,
it appears that as lease size increases, clubs harvest fewer and higher quality deer per acre. Although we analyze properties leased by hunting clubs, the results should be applicable to various other management scenarios. These results have implications for state wildlife agencies and the individual game manager. Certain states have deer management programs that give participants more management flexibility. One of the primary goals of these programs are to increase the quality of deer. A requirement for participation in these programs often includes a minimum lease or property acreage. An optimal minimum acreage requirement should consider the potential benefits to quality illustrated here. For the individual game manager, in conjunction with estimates of hunter willingness to pay, these results may also prove valuable in the decision to cooperation with neighbors or invest in more acreage.

3.6 Concluding Remarks

There is no literature empirically testing the effects of property rights on intrinsic resource quality. This chapter develops a theoretical model analyzing the effects of varying levels ownership on intrinsic resource quality and estimates the developed relationships. We consider the case of deer hunting by hunting clubs on leased properties. Club utility is determined by the quantity and quality of deer harvested. Quality is determined by their harvest decisions. Equation (13) and (14) illustrate how harvest and quality are determined by lease size and ecological variables.

This chapter is the first to incorporate property rights and resource quality into a bioeconomic model. The effect of lease size on quality can be decomposed into three effects; a direct effect, an indirect stock effect, and an indirect harvest effects. Using a time-series cross-

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23 For example, see the Antlerless and Spike-Buck Deer Control Permits Program or the Landowner Assisted Management Permitting System in Texas: http://www.tpwd.state.tx.us/huntwild/wild/game_management/deer/
section from the Mississippi Department of Wildlife and Fisheries with harvest rates and antler measurements for various hunting clubs, we are able to estimate the total effect of lease size on quality. Given data limitations, we are only able to estimate the indirect harvest effect and a combined effect in the form of the sum of the direct effect and indirect stock effect. If stock levels were available, the indirect stock effect could have been estimated separate from the direct effect.

The mechanism considered in our example is driven by externalities. As lease size increases, the level of ownership of the stock increases. As the stock becomes less of a common pool resource, externalities are increasingly internalized and the resource is used more efficiently. In this case, more efficient use corresponds to fewer deer harvested per acre and a higher average quality of deer harvested. Our results support this hypothesis. Club harvest per acre decreases with lease size. Additionally, lease size has a small but significant effect on the average quality of deer harvested. For all clubs with smaller than average hunting leases, a simulated increase to the average size results in approximately a 4.5 percent increase in the average antler index of deer harvested.

The affect of lease size on harvesting behavior may even be reflected in hunting club policies. Hunting clubs usually have a set of standards or rules their members must follow. One of the rules may include a minimum quality threshold for harvesting. This might be a club antler point minimum — where members cannot harvest any deer with few than the minimum antler points. By encouraging members to forgo harvesting lower quality deer, clubs can increase the average quality of deer harvested. As lease size increases, the risk of losing forgone deer to neighboring hunters decreases and clubs may be more willing to impose higher minimum quality
thresholds. The enforcement of these rules depends on the club’s social capital. If a club cannot enforce their agenda, they have a common pool problem within the club itself. Considering these endogenous minimum quality thresholds may be an interesting extension of our analysis.
Chapter 4

Excess Demand and Purchase Options in the Wine Industry

4.1 Introduction

Recurring excess demand has drawn the attention of economists for decades. The classic examples discussed are the long queues for popular restaurants or sold out venues for sporting events, plays, and concerts. Many economists have asked why these firms do not simply increase their prices to reduce queues and the number of turned away fans, all while increasing their profits. Various explanations involving social externalities, adverse selection, or quality signaling have been proposed. However, the previous literature ignores a mechanism often accompanying goods with recurring excess demand - the purchase option. A purchase option grants the consumer the right to purchase the good in future periods. Goods with purchase options and recurring excess demand often have an uncertain future quality. We develop the relationship between excess demand and purchase options and illustrate a mechanism allowing firms to smooth sales across periods with uncertain quality and increase expected profit over the market clearing strategy.

Consider season tickets in the NFL with a positive excess demand in the form of a waiting list. Season tickets holders generally have the option to continue purchasing the same seats in future seasons. The value placed on the option positively depends on the size of the excess demand. Sports fans in general value the quality of play and their team’s performance, both of which can vary significantly from season to season. If the option value is large enough, fans may purchase the season tickets in a season with a low quality of play solely for the option of purchasing season tickets in the next season when the quality of play may be higher. For
example, even with decades of mediocre seasons, the waiting list for Green Bay Packers season tickets is well over 30 years and the organization has successfully smoothed season ticket sales over the entire period. This chapter makes two contributions to the literature — (1) we draw the connection between excess demand and options; (2) we illustrate the case where using excess demand to smooth sales is profit maximizing. Although aspects of the previous literature investigating excess demand may be relevant, this mechanism has not been studied.

Becker (1991) introduces the notion that individual demand may positively depend on aggregate demand. For example, the more fans at an event or patrons at a restaurant, the more enjoyable the experience. Alternatively, for certain events, excess demand and secondary ticket markets serve as a selection process. This ensures low demand consumers, who derive utility from “noise making” and the “happening”, are able to attend (DeSerpa, 1994). These boisterous low demand consumers create a positive externality enjoyed by other fans that shifts the event demand outward. Excess demand in the restaurant context has been explained as a screening process (Ungern-Sternberg, 1991; Bose, 1996). Given restaurants have a fixed capacity, they maximize profit by table per unit of time. Some patrons will be more profitable than others. The rational is that high profit consumers, who want to indulge with family or friends, are more willing to queue than lower profit consumers. Asymmetric information gives rise to another explanation for excess demand. When introducing a new product, monopolies may use excess demand in the initial period to signal quality, and then manipulate inventory levels in following periods to meet demand (Huh, 2003). When quality cannot be signaled using prices, excess demand may be used in the place of advertising to signal a higher quality product and induce a separating equilibrium (Bandyopadhyay et al., 2006 and 2010).
We analyze the case of excess demand in the wine industry. This example has a number of differences from those in previous works. Although consumption of wine can certainly be a social event, it is fundamentally different than attending a play, sporting event, concert, or a restaurant. Unlike tickets or seats, one bottle of wine can be shared by many. In terms of signaling, there is information available \textit{a priori} regarding the quality of wine in the form of wine scores and ratings. These scores and ratings are published by accredited and generally trusted critics. Our analysis also differs from Huh (2003) in that the supply of wine in a given year is predetermined by the supply of wine grapes used to produce it. Firms cannot simply manipulate inventory levels. The central difference however, is our connection between excess demand and purchase options.

To create a purchase option, certain wineries use a wine list to distribute their wines. The wine list guarantees a single price regardless of quality and allocates wine based on list rank, in a top-down fashion. If the consumers on the wine list demand an aggregate quantity greater than the winery’s supply, there is a positive excess demand. Some popular wineries have wine lists large enough they require years to move into a rank high enough to be offered wine. For example, the website of a popular Washington State winery, Leonetti Cellars, reads -

“\textit{Our List is full at this time... The current timeframe to be placed on The List is 3–4 years.}”

If consumers are offered wine, and they decline, they are removed from the list. If a consumer purchases wine, they maintain their rank on the wine list and will be offered wine in the following periods. This mechanism creates the purchase option.
The value consumers place on the purchase option positively depends on cost of their available alternatives. The alternatives include purchasing a substitute or purchasing the wine on the secondary market from other consumers. The availability and cost of substitutes are determined by wine quality. Low quality wines are easily substituted. High quality wines are highly differentiated and there may not be any substitute. If equally priced or cheaper substitutes are available, consumers will not value the purchase option. If there are no perfect substitutes available or the substitutes are more expensive, the excess demand creates an arbitrage opportunity for those that successfully purchased wine from the wine list. Given this opportunity, a secondary market arises where a portion of consumers that successfully purchased wine from the wine list resell their wine to the excess demand for a premium. The higher the quality, the larger the excess demand, and the more expensive the substitutes, the greater the value consumers place on the purchase option.

In terms of quality, wine making is subject to a great deal of uncertainty. The uncertainty stems from both the quality of grapes used and the production process itself. Poor weather can adversely affect the quality of the season’s wine grapes, and subsequently the quality of wine produced. The quality of wine is also determined by a number of variables in the production process. A skilled winemaker will control for as many of these variables as possible. However, the quality of wine is ultimately subject to some minimum level of uncertainty and the possibility of a bad wine year always exists. The purchase option from the wine list provides wineries a mechanism to hedge against poor sales during bad wine years. If a bad wine year occurs, and the value consumers place on the purchase option is high enough, consumers may purchase wine simply for the option of purchasing wine in the next period.
In the next section we develop a theoretical framework motivating the use of a wine list to smooth sales across periods with low quality wine. We relate excess demand and purchase options by illustrating that excess demand plays a critical role in determining consumer willingness to pay for the purchase option. Using this framework, we characterize the firm’s problem. The winery’s problem is to choose a wine list price such that it creates enough excess demand and consumer willingness to pay for the option that consumers purchase bad wine at wine list prices. In section 3, we use a numeric example to illustrate a case where a wine list with positive excess demand is profit maximizing over the market clearing strategy. Concluding remarks are given in section 4.

4.2 Model

For clarity, we begin with preliminaries regarding wine production and the sequence of marketing events. We breakdown the process to a six stage model. The stages are as follows:

1. In the first stage, wineries procure wine grapes. To procure wine grapes, wineries either contract with vineyards or vertically integrate and produce their own. The quality of wine grapes is essential in determining the quality of wine produced. The timing of their harvest is crucial and must be done at the optimal ripeness. For wineries contracting their supply of wine grapes, it can be difficult to verify quality and best harvesting practices. The organizational economics literature suggests when input quality and best practices are difficult to verify, in-house production often results (Mahoney, 1992). Wineries concerned with quality are indeed more likely to vertically integrate, producing their own wine grapes (Fernández-Olmos et al. 2009). Anecdotally, wineries operating wine lists with recurring excess demand also tend to produce
their own wine grapes. Producing wine grapes in-house requires operating a vineyard and the necessary vineyard capital. Varying wine output is costly as it will require varying the quantity of wine grapes produced. This involves procuring additional vineyard capital or liquidating, renting, or allow sitting idle existing capital. All of which include costs.

(2) In the second stage, wineries make wine. Winemaking itself involves capital in the form of crushers, presses, tanks, conveyers, tables, filtration, and bottling equipment.

(3) In the third stage, the wine is aged. Aging wine requires climate controlled storage space. Wines usually age a minimum of one year. High quality wines are often aged three or more years before being bottled and sold.

(4) In the fourth stage, the final quality of wine is revealed to the winery.

(5) In the fifth stage, the wine is sold. Should the winery employ a market clearing strategy, prices are set according to quality. If the winery is employing a wine list, the wine will be offered to those on the list at the wine list price.

(6) In the sixth stage, excess demand and secondary markets form. If the winery’s supply is sold out through the wine list and consumers still demand wine, there exists a positive excess demand. The excess demand creates an arbitrage opportunity for those consumers that successfully purchased wine. A portion of consumers that successfully purchased wine capitalize on this opportunity by reselling their wine to the excess demand for a premium. Refer to this as the secondary market. The equilibrium secondary market price, where the quantity resold clears the excess demand, depends on the relationship between the quantity of wine resold for arbitrage and the size of excess demand.

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24 Two wineries in Washington that consistently maintain an excess demand for their wine lists are Leonetti Cellars and Cayuse Vineyards. Both produce their own wine grapes.
Our analysis focuses on fifth and sixth stages. We develop the relationships between the wine list price, excess demand, the equilibrium secondary market price, and the value consumers place on the purchase option. The remainder of this section is divided into five subsections. In subsection 4.2.1 we illustrate the case for the profit maximizing wine list. The purpose of this section is to illustrate that a wine list may be profit maximizing over a market clearing strategy. In subsection 4.2.2 we develop the relationship between excess demand and secondary markets. Specifically, we show the effect of excess demand on secondary market prices. For use in the following subsection, this result is important to establish. Consumer willingness to pay for the purchase option is determined by secondary market prices. In subsection 4.2.3 we illustrate the relationship secondary market prices and the purchase option. Subsection 4.2.4 incorporates consumer willingness to pay for the purchase option into demand for the wine list and illustrate the effect of excess demand. Finally, in subsection 4.2.5, we characterize the firm’s profit maximization problem where a wine list price is chosen to determine the optimal level of excess demand.

4.2.1 The Profit Maximizing Wine List

Given the timing of sourcing wine grapes, the aging process, the timing of wine quality information, and the large capital requirement, assume the winery’s output is fixed at $Q$. There are two levels of wine quality – high and low. Wine quality is high with probability $\alpha$ and low with probability $(1-\alpha)$. Consumer utility is concave, $U' > 0$ and $U'' \leq 0$. High quality wine is preferred to low quality wine, $U^h > U^l > 0$. The winery is a monopoly and sets market clearing prices $P^h$ and $P^l$ for high and low quality wine, where $P^h > P^l$. Conditional on an output of $Q$ and using a market clearing strategy, $P^h$ and $P^l$ maximize profits for high and low quality.
Assume the firm is risk-neutral. Costs do not vary between high and low quality and are fixed at $C$.

Assume the winery uses a wine list to distribute their wine, guaranteeing a price of $P^*$, where $P^l < P^* < P^h$. For the moment suppose that the quantity demanded, $D$, at the wine list price is greater than or equal to $Q$, regardless of quality. That is $D^k(P^*) \geq Q$ for $k = h, l$. This generates a profit of $\pi^* = P^*Q - C$ with certainty. The market clearing profits are $\pi^h = P^hQ - C$ and $\pi^l = P^lQ - C$ for high and low quality. The expected profit of the market clearing strategy is,

$$E[\pi^*] = \alpha(P^hQ - C) + (1 - \alpha)(P^lQ - C) = \alpha\pi^h + (1 - \alpha)\pi^l.$$ 

The wine list costs the firm foregone revenue when quality is high, while it benefits the firm with additional revenue when quality is low. The expected cost of the wine list is the weighted profit difference between charging the wine list price and the high quality market clearing price, $\alpha(\pi^h - \pi^*)$. The expected benefit is the weighted profit difference between charging the wine list price and the low quality market clearing price, $(1 - \alpha)(\pi^* - \pi^l)$. The firm prefers the wine list over the market clearing strategy when the expected benefit is greater than or equal to the expected cost,

$$(1 - \alpha)(\pi^* - \pi^l) \geq \alpha(\pi^h - \pi^*). \quad (1)$$

The wine list profit at which the firm is indifferent between employing the wine list and the market clearing strategy is referred to as the certainty equivalent. Denote the certainty
equivalent $\pi$. Replacing the wine list profit with the certainty equivalent causes (1) to hold with equality. Rewriting (1) in terms of the certainty equivalent,

$$\alpha \pi^h + (1-\alpha) \pi^l = \pi.$$ 

Denote the price associated with the certainty equivalent $P$. This represents a single price, where if $Q$ units were sold, the profit would equal the certainty equivalent, $\pi = PQ - C$. 

Proposition 1: Given the market clearing profits and certainty equivalent defined above, if we have a wine list price such that $P \leq P^*$ and $D^k(P^*) \geq Q$ for $k = h, l$, then

$$\alpha \pi^h + (1-\alpha) \pi^l \leq P^*.$$ 

A proof for proposition 1 can be found in appendix 4.1. In words, proposition 1 states a wine list price greater than or equal to the certainty equivalent, and such that the winery sells its entire supply of $Q$, will maximize profit over the market clearing strategy.

The question is, how can the firm charge $P^* > P^i$ and expect to sell $Q$ units when quality is low? In the following sections we demonstrate using a wine list with positive excess demand and purchase options enable firms to smooth sales when quality is low. The wine list price generates excess demand when quality is high. Combined with the purchase option, this increases consumer willingness to pay for low quality wine past market clearing levels. To smooth sales and ensure a profit of $\pi^*$, firms must price their wine such that the excess demand is large enough to increase the value consumers place on the purchase option and make purchasing low quality wine, with the purchase option, a utility maximizing alternative.
4.2.2 Secondary Markets

The thread connecting excess demand and purchase options is the secondary market. Before we discuss the effect of excess demand on the purchase option, it is important to understand the relationship between excess demand and secondary markets. Because purchasing wine on the secondary market does not include the purchase option offered by the winery, we begin using a demand that does not consider the purchase option. Assume an economy with \( n \) identical consumers, each with a fixed income of \( Y \), where only wine is consumed. Excess demand occurs when the quantity demanded exceeds the quantity supplied. Letting \( E \) and \( D \) denote excess demand and aggregate demand, given a price of \( P^* \) and a quantity of \( Q \), excess demand is,

\[
E(D^h(Y, P^*)) = D^h(Y, P^*) - Q. \tag{2}
\]

Given a consumer income of \( Y \), \( D^h \) is the quantity of high quality wine demanded at a price of \( P^* \). This demand is solely determined by consumer willingness to pay for high quality wine. Again, it does not include the consumer willingness to pay for the purchase option.

If the wine list price is less than the market clearing price, there is positive excess demand. Consumers not able to purchase wine for \( P^* \) through the wine list make up the excess demand and face the secondary market. Even if consumers are able to purchase from the wine list, there are frequently quantity limits to discourage arbitrage, so those wishing to consume over the quantity limit are also forced to the secondary market.

The secondary market demand is determined by the level of excess demand. Specifically, secondary market demand is determined by the level of residual consumer income,
or income that consumers wished to spend on the wine but were unable to due to the excess demand. This assumes consumers are not able to substitute for the wine. The income that reaches the secondary market is

\[ Y^* = nY - P^s Q = P^s E \left( D^h (Y, P^s) \right). \]

As excess demand increases, so does the amount of income in the secondary market, \( dY^*/dE = P^s > 0 \). Denote secondary market prices \( \tilde{P}^h \) and \( \tilde{P}^l \). Define the secondary market demand for high quality wine in terms of income and price,

\[ D^s = D^h \left( Y^*, \tilde{P}^h \right). \]

For simplicity, we assume a fixed quantity of high quality wine is resold on the secondary market. Denote the supply of the secondary market, \( Q' \). The secondary market reaches equilibrium where,

\[ D^h \left( Y^*, \tilde{P}^h \right) = Q'. \]

Let \( \hat{P}^h \) denote the equilibrium secondary market price for high quality wine. Implicitly solving for \( \hat{P}^h \) in terms of secondary income and supply, we have

\[ \hat{P}^h = \hat{G} \left( Y^*, Q' \right) = \hat{G} \left( P^s E \left( D^h \left( Y, P^s \right) \right), Q' \right). \] (3)

We assume there are perfect substitutes for low quality wine, and the equilibrium secondary market price for low quality wine is equal to the market clearing price, \( \hat{P}^l = P^l \). Assuming high quality wine is a normal good, the equilibrium secondary market price is increasing in income,

\[ \text{Realistically, the quantity resold on the secondary market will depend on consumer heterogeneity. Only those consumers with a consumer surplus less than the profit available from arbitrage will engage in reselling on the secondary market. The simplifying assumption expedites this discussion in an already cumbersome model.} \]
\( d\hat{G}/dY > 0 \). A change in excess demand will affect the equilibrium high quality secondary market price through secondary market income,

\[
\frac{d\hat{P}^h}{dE} = \frac{\partial \hat{G}}{\partial Y^s} \frac{dY^s}{dE} > 0.
\] (4)

Figure 4.1 illustrates the relationship between the wine list price for high quality wine, excess demand, and the secondary market for wine. The price \( P^* \) results in the excess demand \( E \). This level of excess demand determines the demand curve for the secondary market, \( D_s \). Given a quantity of wine resold on the secondary market equal to \( Q^s \), the equilibrium secondary market price is \( \hat{P}^h \).

**Figure 4.1 Secondary Markets**
Now consider the effect a change in excess demand has on secondary market prices. In figure 4.2 we illustrate the effects of a decrease in the wine list price. Assume the wine list price decreases from $P^*$ to $P^{**}$. This results in a larger quantity demand, and increases the excess demand from $E$ to $E_2$. As excess demand increases, more consumers enter the secondary market and the secondary market demand shifts outward, from $D'$ to $D'_2$. The shift in demand results in an increase in the equilibrium secondary market price from $\hat{P}^h$ to $\hat{P}^h_2$.

**Figure 4.2 Excess demand and Secondary markets**

Let us take stock. The goal of this subsection was to illustrate (4). This result is important in further developing the relationship of excess demand and the purchase option.
4.2.3 Options

In this subsection we illustrate the mechanism through which excess demand affects the purchase option, which is closely related to the secondary market. To create an option, let the winery employ a wine list that includes an option to purchase in future periods at a guaranteed wine list price of $P^*$. Consumers receive two benefits from the wine list: the value they derive from consuming the wine they purchase and the value they place on the purchase option. Refer to the value consumers place on the purchase option as the option price. The option price is the consumer’s maximum willingness to pay for the option, guaranteeing a price of $P^*$ in the next period regardless of quality. The option price is not a per unit measure. They are only willing to pay the option price once per period, regardless of quantity demanded.

Consumers will pay an option price, before wine quality is known, up to the point where they are indifferent between doing so and relying on the secondary markets. The expected utility of paying the option price will equal the expected utility of relying on the secondary markets. Borrowing from the options literature, we can illustrate the relationship between option price and secondary market prices using indirect utility functions (Schmalensee, 1972). Let $O$ denote option price,

$$
aU^h(Y - O, P^*) + (1 - \alpha)U^i(Y - O, P^*) = \alpha U^h(Y, \hat{P}^h) + (1 - \alpha)U^i(Y, \hat{P}^i). \tag{5}
$$

It is also useful to define indirect utility functions in terms of conditional equivalent variations. The conditional equivalent variation is the maximum a consumer is willing to pay for the option conditional on wine quality. The expected utility of paying the conditional equivalent
variations will equal the expected utility of relying on the secondary markets. Let $SE^h$ and $SE^l$ denote the consumer’s equivalent variation for high and low quality wine,

$$\alpha U^h(Y - SE^h, P^*) + (1 - \alpha)U^l(Y - SE^l, P^*) = \alpha U^h(Y, \hat{P}^h) + (1 - \alpha)U^l(Y, \hat{P}^l). \quad (6)$$

Notice the right hand side of (5) and (6) is the expected utility of consuming wine purchased on the secondary market. Equating (5) and (6) and simplifying, we have,

$$\alpha \left[ U^h(Y - O, P^*) - U^h(Y - SE^h, P^*) \right] + (1 - \alpha) \left[ U^l(Y - O, P^*) - U^l(Y - SE^l, P^*) \right] = 0 \quad (7)$$

Given the concavity of utility, we know,$^{26}$

$$U^h(Y - O, P^*) - U^h(Y - SE^h, P^*) \geq (SE^h - O)U^h_y(Y - SE^h, P^*) \quad (8)$$

and

$$U^l(Y - O, P^*) - U^l(Y - SE^l, P^*) \geq (SE^l - O)U^l_y(Y - SE^l, P^*). \quad (9)$$

Substituting (8) and (9) into (7),

$$\alpha (SE^h - O)U^h_y(Y - SE^h, P^*) + (1 - \alpha) (SE^l - O)U^l_y(Y - SE^l, P^*) \leq 0.$$

---

$^{26}$ The average slope between the points $U^h(Y - O, P^*)$ and $U^h(Y - SE^h, P^*)$ on the utility curve is

$$\frac{U^h(Y - O, P^*) - U^h(Y - SE^h, P^*)}{(Y - O) - (Y - SE^h)}.$$

The slope of utility at $U^h(Y - SE^h, P^*)$ is $U^h_y(Y - SE^h, P^*)$. Given the conditional equivalent variation when quality is high is greater than the option price, the average slope between $U^h(Y - O, P^*)$ and $U^h(Y - SE^h, P^*)$ must be greater than the slope at the point $U^h(Y - SE^h, P^*)$, or

$$\frac{U^h(Y - O, P^*) - U^h(Y - SE^h, P^*)}{(Y - O) - (Y - SE^h)} \geq U^h_y(Y - SE^h, P^*).$$

This can be rewritten $U^h(Y - O, P^*) - U^h(Y - SE^h, P^*) \geq (SE^h - O)U^h_y(Y - SE^h, P^*)$. The same reasoning can be applied to find (9).
Finally, solving for option price in terms of the conditional equivalent variations,

$$O \geq \frac{SE^h \alpha U^h_Y (Y - SE^h, P^*) + SE^l (1 - \alpha) U^l_Y (Y - SE^l, P^*)}{\alpha U^h_Y (Y - SE^h, P^*) + (1 - \alpha) U^l_Y (Y - SE^l, P^*)}.$$  

(10)

Condition (10) states the weighted expected consumer’s surplus, at levels of income of $Y - SE^h$ and $Y - SE^l$, will be less than or equal to the option price. For the risk neutral consumer, (10) holds with equality and the marginal utilities of income are constant.

The conditional equivalent variations are equal to the difference between the income needed to maintain the wine list levels of utility, given secondary market prices, and the original level of income. They are usually expressed as the difference between the hypothetical expenditure function and original income. Denoting the expenditure function $e$, the utility of the wine list for high and low quality $U^{h,w}$ and $U^{l,w}$, and the corresponding Hicksian demands $H^h (\hat{P}^h, U^{h,w})$ and $H^l (\hat{P}^l, U^{l,w})$, the conditional equivalent variations are

$$SE^h = e (\hat{P}^h, U^{h,w}) - Y = \hat{P}^h H^h (\hat{P}^h, U^{h,w}) - Y$$

and

$$SE^l = e (\hat{P}^l, U^{l,w}) - Y = \hat{P}^l H^l (\hat{P}^l, U^{l,w}) - Y.$$ 

Excess demand affects the conditional equivalent variations through the secondary market price for high quality wine and the wine list utilities. Recall excess demand does not affect the secondary market price for low quality wine. The comparative statics are,

$$\frac{dSE^h}{dE} = \frac{\partial SE^h}{\partial \hat{P}^h} \frac{d\hat{P}^h}{dE} H (\hat{P}^h, U^{h,w}) + \frac{\partial SE^h}{\partial H (\hat{P}^h, U^{h,w})} \frac{\partial H (\hat{P}^h, U^{h,w})}{\partial U^{h,w}} \frac{dU^{h,w}}{dE} \hat{P}^h$$
and

\[
\frac{dSE^i}{dE} = \frac{\partial SE^i}{\partial H\left(\hat{P}^j, U^{i,w}\right)} \frac{\partial H\left(\hat{P}^i, U^{i,w}\right)}{\partial U^{i,w}} \frac{dU^{i,w}}{dE} \hat{P}^i.
\]

By definition \(\frac{\partial SE^h}{\partial \hat{P}^h} = H^h\left(\hat{P}^h, U^{h,w}\right) > 0\). Recall (4). The secondary market price for high quality wine positively depend on excess demand, \(d\hat{P}^h/dE > 0\). By definition \(\frac{\partial SE^h}{\partial H^h\left(\hat{P}^h, U^{h,w}\right)} = \hat{P}^h > 0\). Similarly, we also know Hicksian demands are increasing in wine list utility, \(\frac{\partial H\left(\hat{P}^k, U^{k,w}\right)}{\partial U^{k,w}} > 0\). To determine the effect to of excess demand on wine list utility, consider the indirect utility function

\[
U^k(Y, P^*) = U^{k,w} \text{ for } k = h, l.
\]

The effect of excess demand on utility is,

\[
\frac{dU^k}{dE} = \frac{\partial U^k}{\partial P^*} \frac{dP^*}{dE}.
\]

By definition, indirect utility functions are decreasing in price, \(\partial U^k / \partial P^* < 0\). From (2) we can solve for an inverse excess demand function,

\[
P^* = G^*\left(E, Y, Q\right).
\]

Analogous to a traditional inverse demand function and quantity demanded, this function is decreasing in excess demand, \(dP^*/dE < 0\). This is illustrated in figure 4.3. At \(P^h\) there is zero excess demand. At \(P^*\) there is an excess demand of \(E_1\). At \(P^{**}\) there is an excess demand of \(E_2\).
With this result, we know wine list utility positively depends on excess demand, $dU^{k,w}/dE > 0$, and as a result the same is true for the conditional equivalent variations,

$$\frac{dSE^h}{dE} > 0.$$  

Assuming risk neutral consumers, we can rewrite (10) as,

$$O = \frac{SE^h \alpha U^h_Y + SE^l (1-\alpha)U^l_Y}{\alpha U^h_Y + (1-\alpha)U^l_Y}. \quad (12)$$  

Differentiating (12), we have the effect of excess demand on the option price,

$$\frac{dO}{dE} = \frac{\partial O}{\partial SE^h} \frac{dSE^h}{dE} + \frac{\partial O}{\partial SE^l} \frac{dSE^l}{dE}. $$
It is clear the option price is increasing in the conditional equivalent variations, \( dO/dSE^k > 0 \). As we just illustrated, the conditional equivalent variations are increasing in excess demand, \( dSE^k/dE > 0 \). Finally, we can conclude that the option price is also increasing in excess demand, 

\[
\frac{dO}{dE} > 0.
\]

For use in later sections, it is useful to denote option price as a function of the wine list price. Substituting (3) and (11) into the conditional equivalent variations in (12), we have,

\[
O\left(\alpha, \hat{P}^i, \hat{G}\left(P'E\left(D^h\left(Y,P^r\right)\right),Q^r\right),U^h\left(Y,P^r\right),U^l\left(Y,P^r\right)\right)
\]

or

\[
O\left(\alpha, \hat{P}^i, Q^r,Y,P^r\right).
\]

To summarize, we have established the following: excess demand increases secondary market prices, secondary market prices and excess demand increase the conditional equivalent variations, and finally through these results, excess demand increases the option price.

4.2.4 Demand

With the results from the previous subsection, we now focus on demand. Recall the consumer receives two benefits from the wine list: the value they derive from consuming the wine and the value they place on the purchase option. The value placed on consuming wine can be represented by an inverse demand function. Denote individual consumer demand for wine \( d^k \) for \( k = h,l \). The inverse demand function specifies a price per unit demanded,
\[ P^k = G^k \left( d^k \right) \text{ for } k = h, l. \] The value of consuming a quantity of wine equal to \( d^k \) is given by \( G^k \left( d^k \right) d^k \). The value consumers place on the purchase option is the option price, \( O\left( \alpha, \hat{P}^i, Q^s, Y, P^s \right) \). The wine list simply combines the two benefits into a single price.

Letting \( d^{w,k} \) for \( k = h, l \) denote quantity of wine demanded from the wine list, the value consumers place on the wine list at a quantity of \( d^{w,k} \) is then,

\[
P^* d^{w,k} = G^k \left( d^{w,k} \right) d^{w,k} + O\left( \alpha, \hat{P}^i, Q^s, Y, P^s \right).
\]

Recall the option price is not a per unit price. It is a single payment, regardless of quantity demanded. With the purchase option, guaranteeing a price of \( P^* \), and with a quantity demanded of \( d^{w,k} \), the consumer is willing to spend an amount of money equal to \( G^k \left( d^{w,k} \right) d^{w,k} + O\left( \alpha, \hat{P}^i, Q^s, Y, P^s \right) \). The inverse wine list demand is,

\[
P^* = G^k \left( d^{w,k} \right) + \frac{O\left( \alpha, \hat{P}^i, Q^s, Y, P^s \right)}{d^{w,k}}.
\]

As the option price increases, consumer willingness to pay for the wine list increases. Resolving for individual demand as a function of wine list price and the option price, we have

\[
d^{w,k} \left( P^*, O\left( \alpha, \hat{P}^i, Q^s, Y, P^s \right) \right) \text{ for } k = h, l.
\]

Aggregating individual demand over the \( n \) consumers, the wine list demand is

\[
D^{w,k} = nd^{w,k} \left( P^*, O\left( \alpha, \hat{P}^i, Q^s, Y, P^s \right) \right)
= F^k \left( P^*, O\left( \alpha, \hat{P}^i, Q^s, Y, P^s \right) \right) \text{ for } k = h, l.
\]

Finally, the effect of excess demand on wine list demand is,
Excess demand increases demand for the wine list. This result is paramount. Recall the question posed during the end of the first subsection — how can the firm charge $P^* > P^i$ and expect to sell $Q$ units when quality is low? Using excess demand and a purchase option, the firm creates an option price that, combined with the consumer willingness to pay for low quality wine, may induce consumers to purchase low quality wine for $P^* > P^i$. The results of this section illustrate the two facets of the mechanism behind the wine list; (1) excess demand increases option price, and (2) option price increases wine list demand. The winery’s problem is to choose a wine list price such that it creates enough excess demand and consumer willingness to pay for the option that consumers are willing purchase wine for the guaranteed price when quality is low.

4.2.5 The firm’s problem

The wine list guarantees a single price for both good and bad wine. The winery’s problem is to choose a wine list price such that it maximizes expected profit. Expected profit is,

$$E[\pi | P^*] = \alpha \left[ P^* \left( F^h \left( P^*, O \left( \alpha, \hat{P}^i, Q^*, Y, P^* \right) \right) - E \left( D^h \left( Y, P^* \right) \right) \right) - C \right] + (1 - \alpha) \left[ P^* \left( F^l \left( P^*, O \left( \alpha, \hat{P}^i, Q^*, Y, P^* \right) \right) - C \right) \right]$$

The firm faces two supply constraints,

$$Q \geq F^h \left( P^*, O \left( \alpha, \hat{P}^i, Q^*, Y, P^* \right) \right) - E \left( D^h \left( Y, P^* \right) \right)$$

27 Even though quality is known, differential pricing may be considered unfair by consumers (Kahneman et al, 1986).
and

\[ Q \geq F^l(P^*, O(\alpha, \hat{P}^l, Q^*, Y, P^*)). \]  

(15)

These constrain the quantity sold, ensuring they do not sell a quantity greater than \( Q \). Allowing the possibility for a surplus, where the firm does not sell \( Q \), we define excess demand as,

\[ E(D^h(Y, P^*)) = \max \left\{ 0, F^h(P^*, O(\alpha, \hat{P}^l, Q^*, Y, P^*)) - Q \right\}. \]

The firm maximizes (13) subject to (14) and (15) by choosing \( P^* \):

\[ \max_{P^*} E[\pi] \]

s.t. \( Q \geq F^h(P^*, O(\alpha, \hat{P}^l, Q^*, Y, P^*)) - E(D^h(Y, P^*)) \)

\( Q \geq F^l(P^*, O(\alpha, \hat{P}^l, Q^*, Y, P^*)). \)

For compactness, in the remainder of this section we remove the parameters when writing functions and their partial derivatives. The Lagrangian for the above problem is,

\[ L = E[\pi] + \lambda_1[Q - F^h + E] + \lambda_2[Q - F^l] \]

(16)

where \( \lambda_1 \) and \( \lambda_2 \) are the Lagrangian multipliers of the constraints on the supply. The Kuhn-Tucker conditions that solve (16) are:

\[ \frac{\partial L}{\partial P^*} = \alpha(F^h - E) + (1 - \alpha)(F^l) + \alpha P^* \left( F^h_P + F^h_Q O_P - E_D D^h_P \right) + \]

\( \left( 1 - \alpha \right) P^* \left( F^l_P + F^l_Q O_P \right) + \lambda_1 \left[ -F^h_P - F^h_Q O_P + E_D D^h_P \right] + \lambda_2 \left[ -F^l_P - F^l_Q O_P \right] \leq 0, \text{ with } P^* \geq 0, \ P^* \frac{\partial L}{\partial P^*} = 0 \]
\[ \frac{\partial L}{\partial \lambda_i} = Q - F^h + E \geq 0, \text{ with } \lambda_i \geq 0, \lambda_i \frac{\partial L}{\partial \lambda_i} = 0 \]  
(18)

\[ \frac{\partial L}{\partial \lambda_2} = Q - F^l \geq 0, \text{ with } \lambda_2 \geq 0, \lambda_2 \frac{\partial L}{\partial \lambda_2} = 0. \]  
(19)

Not considering the trivial solution, there are four possible cases that satisfy (17)-(19) and optimize (16). The four cases are: (case 1) conditions (17) through (19) are binding; (case 2) condition (17) and (18) are binding while (19) is nonbinding; (case 3) condition (17) is binding while both (18) and (19) are nonbinding; and (case 4) where (17) and (19) are binding and (18) is non-binding.

Case 1

There are two sub-cases when (17) through (19) are binding —excess demand for high quality wine, while the market for low quality wine either clears or has excess demand.

When the low quality market clears, the marginal consumer values consuming low quality wine at \( V^l \). The wine list price is equal to the sum of the marginal consumer’s value of consuming low quality wine and the per unit option price,

\[ P^*d^{w,l} = V^l d^{w,l} + O \quad \text{or} \quad P^* = V^l + \frac{O}{d^{w,l}}. \]  
(20)

By definition, \( F^h_{p^*} = D^h_{p^*} \), and \( F^l_{p^*} = D^l_{p^*} \). We can rewrite (17) as,

\[
\alpha (F^h - E) + (1-\alpha) F^l = -\alpha P^* F^h_{p^*} O_{p^*} - (1-\alpha) P^*(F^l_{p^*} + F^l_{p^*} O_{p^*}) \\
+ \dot{\lambda}_1 F^h_{p^*} O_{p^*} + \dot{\lambda}_2 [F^l_{p^*} + F^l_{p^*} O_{p^*}] .
\]  
(21)

The left-hand side of (21) is the marginal benefit of a price increase, or the marginal profit from the additional revenue. The first and second terms on the right-hand side taken together are the expected marginal loss associated with an increase in wine list price. This
reduction results from a smaller demand and excess demand when quality is high, a smaller
demand when quality is low, and a reduced option price. The third and fourth terms on the right-
hand side are the opportunity costs of the option price for high and low quality wine.

When the low quality market also has excess demand, (20) becomes

$$P^* d_{w,l} < V^l d_{w,l} + O \quad \text{or} \quad P^* < V^l + \frac{O}{d_{w,l}}.$$  

However, if (17) through (19) are binding, a profit maximizing firm will not price their wine
such that excess demand in the low quality market occurs. Excess demand in the low quality
market is costing the firm additional revenue for both high and low quality wine. If a positive
excess demand exists in the low quality market, increasing the wine list price will increase
profits in both the high and low quality market, without reducing the quantity sold. The profit
maximizing firm will increase the wine list price until the low quality market clears.

Case 2

There are also two sub-cases when condition (17) and (18) are binding and (19) is nonbinding —
the market for high quality goods can either clear or have excess demand, while there is a surplus
of low quality goods.

When the high quality market clears, the marginal consumer values consuming high
quality wine at $V^h$. However, when the market clears, no excess demand exists and the option
price is zero. The wine list price is equal to the marginal consumer’s value of high quality wine
or the original market clearing price for high quality wine, $P^* = V^h = P^h$. 
This is not a profit maximizing strategy. When quality is high, the firm’s profit is equal to the market clearing profit $\pi^h$. However, when quality is low, the firm is charging the high quality market clearing price. Given, $P^h > P^l$, this results in a surplus. Recall costs are sunk and the profit associated with $P^l$ and $Q$ is maximized given a zero option price. Without a strictly positive option price, charging a price greater than $P^l$ necessarily results in a profit smaller than $\pi^l$. The expected profit under this strategy is less than that of simply charging market clearing price and the firm is better off not employing a wine list.

When the high quality market has excess demand, the option price is greater than zero and the wine list price is such that,

$$P^*d^{w,h} < V^h d^{w,h} + O$$ or $$P^* < V^h + \frac{O}{d^{w,h}}.$$  

The option price is not large enough to clear the market when quality is low,

$$P^*d^{w,l} > V^l d^{w,l} + O$$ or $$P^* > V^l + \frac{O}{d^{w,l}}.$$  

In order for this case to optimize (16), the expected profit would need to be greater than or equal to that of case 1,

$$\alpha P^*_2 Q + (1-\alpha) F^*_2 > P^*_1 Q$$  

or

$$\alpha \left( P^*_2 Q - P^*_1 Q \right) > (1-\alpha) \left( F^*_2 - F^*_1 \right).$$

(22)

The right-hand side of (22) can be thought of as the gain and the left-hand side as the cost of increasing the wine list price above that of case 1. In order for (22) to hold, the price elasticity of
demand must be such that the reduced demand when quality is low results in a loss in revenue outweighed by the gain in revenue when quality is high.

Case 3 and 4

In case 3, when condition (17) is binding and both (18) and (19) are nonbinding, there is a surplus of both high and low quality goods. For similar reasoning outlined in the first sub-case of case 2, where the option price is zero, this cannot maximize expected profit. The firm is better off not employing the wine list and simply charging market clearing prices. Case 4 occurs where (17) and (19) are binding and (18) is non-binding. Given that \( U^h > U^l > 0 \) and \( F^h > F^l \), we know that if (19) is binding, (18) must also bind. Therefore case 4 cannot optimize (16) and is not a solution.

4.3 Numeric example

To illustrate that a positive excess demand may be profit maximizing, we simulate the wine list and compare profit levels with the expected profit of the market clearing strategy. Following our previous example, quality is high or low with probabilities \( \alpha \) and \( 1 - \alpha \). The winery produces a fixed amount \( Q \) and faces fixed costs of \( C \). Once produced, quality is known by the winery and consumers. High and low quality markets clear at prices of \( p^h \) and \( p^l \), generating profits of \( \pi^h \) and \( \pi^l \). The firm chooses a single wine list price, \( p^* \), that maximizes profits and satisfies (17)-(19). Denote this profit \( \pi^w \).

Consumers derive utility from two goods – wine, \( q \), and a numéraire, \( q_n \). The numéraire’s price is normalized to one. Consumer income is fixed at \( y \). Utility is determined by a Cobb-Douglas style utility function,
\[ U^k(q, q_n) = \delta_i q_i^\beta_i q_n^{1-\beta_i} \quad \text{for} \quad k = h, l, \]

where \( \delta_h > \delta_i > 0 \) and \( 1 > \beta_h > \beta_i > 0 \). Notice this implies consumers are risk neutral.

Individual demand for wine is

\[ q = \frac{\beta_k y}{p^k} \quad \text{for} \quad k = h, l. \]

Demand for the wine list including the per unit option price is

\[ q = \frac{\beta_k y + O}{p^*} \quad \text{for} \quad k = h, l \]

There are \( N \) identical consumers, yielding aggregate demands of

\[ D^k = \frac{N \beta_k y}{p^k} \quad \text{for} \quad k = h, l \]

when markets clear and

\[ D = \frac{N(\beta_k y + O)}{p^*} \quad \text{for} \quad k = h, l \]

for the wine list. This specification assumes the price elasticity of demand for wine is equal to -1. The literature suggests this is not a departure from reality. In a meta-analysis of 132 alcohol demand studies, Gallet (2007) estimates the price elasticity for wine to be -1.1.

We assume a fixed portion of the total quantity reaches the secondary market. Denote this quantity \( Q^s \). When quality is high, the wine list price is below the market clearing price and a positive excess demand exits. This excess demand and the secondary market supply determine the secondary market price when quality is high, \( \hat{p}^h \). Substitutes for low quality wine exist, and we assume the secondary market price for low quality wine is equal to the market clearing price.
Because consumers are risk neutral, we know (11) holds with equality and we can calculate the option price. To calculate the option price, we require the conditional equivalent variations and the marginal utilities of money. The conditional equivalent variations measure the consumer’s willingness to pay to go from the secondary market prices to the wine list price. In other words, the difference between the expenditure necessary to achieve the level of utility derived from the wine list at secondary market prices and consumer wealth. Denote the utility of the wine list $U^{h,w}$ and $U^{l,w}$ for high and low quality. The conditional equivalent variations are

$$SE^h = e(p^h, U^{h,w}) - y = \frac{U^{h,w}(\beta_h)}{\delta_h} (1 - \beta_h)^{\delta_h} - y > 0$$

and

$$SE^l = e(p^l, U^{l,w}) - y = \frac{U^{l,w}(\beta_l)}{\delta_l} (1 - \beta_l)^{\delta_l} - y < 0.$$ 

The marginal utilities of money are

$$U^k_y = \delta_k \left( \frac{\beta_k}{\hat{p}^k} \right)^{\beta_k} \left( 1 - \beta_k \right)^{1-\beta_k} \text{ for } k = h, l.$$ 

Using the above we can calculate the option price.

The model parameterization is found in table 4.1. The probability of high quality wine is 0.7. The utility scalars are 10 and 2 for high and low quality wine. Similarly, wine income shares are 0.5 and 0.4 for high and low quality. The economy is scaled at 1000 consumers with an income of $10,000 each. The firm produces 100,000 units. We assume 3 percent of high quality wine is sold on the secondary market. This small portion was chosen to relate the simulated secondary market prices to reality, ensuring secondary market prices for high quality wine exceed market clearing prices.
In table 4.2, we see market clearing prices are $50 and $40 for high and low quality wine, generating profits of $4.999 and $3.999 million. The expected profit from the market clearing strategy is $4.699 million. The certainty equivalent price for this level of profit is $46.99. The firm is indifferent between the profit generated by the certainty equivalent price and the expected profit from the market clearing strategy. Any wine list price above the certainty equivalent price that does not create a surplus when quality is low will increase expected firm profit.
Table 4.3 presents the results for the profit maximizing wine list. The firm maximizes profit with a wine list price of $48.10. This generates an excess demand of 3949.32 units and a secondary market price of $63.32. The resulting option price is $810.04. That is, the consumer is willing to pay $810.04 for the option of purchasing wine from the wine list in the next period, as opposed to the secondary market. The per unit option price is $8.10, and we see that (20) holds and the low quality market clears. Increasing the wine list price at all, causing a surplus when quality is low, reduces the firm’s expected profit. This illustrates case 1, not case 2, optimizes (16), and the profit maximizing firm will increase the wine list price until (20) holds.

<table>
<thead>
<tr>
<th>Table 4.3 The Wine List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wine list price</td>
</tr>
<tr>
<td>Secondary market quantity demand</td>
</tr>
<tr>
<td>Secondary market price (high quality)</td>
</tr>
<tr>
<td>Equivalent variation (high)</td>
</tr>
<tr>
<td>Equivalent variation (low)</td>
</tr>
<tr>
<td>Marginal utility of money (high)</td>
</tr>
<tr>
<td>Marginal utility of money (low)</td>
</tr>
<tr>
<td>Option price</td>
</tr>
<tr>
<td>Option price (per unit)</td>
</tr>
<tr>
<td>Wine list profit (millions)</td>
</tr>
</tbody>
</table>

Table 4.4 compares the market clearing and wine list profits. The wine list generates a profit of $4,809,036 million. When quality is high, wine list profit is $189,964 lower than the market clearing strategy. This is the cost of the wine list. However, when quality is low, the wine list profit is $810,036 higher than the market clearing strategy. The wine list increases the firm’s expected profit $110,036, or 2.34 percent. This illustrates the winery is better off employing a wine list with positive excess demand than setting market clearing prices.
### Table 4.4 Profit Comparison

<p>| | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Market clearing profit when high (millions)</td>
<td>$4.999</td>
</tr>
<tr>
<td>Market clearing profit when low (millions)</td>
<td>$3.999</td>
</tr>
<tr>
<td>Market clearing expected profit (millions)</td>
<td>$4.699</td>
</tr>
<tr>
<td>Wine list expected profit (millions)</td>
<td>$4,809,036</td>
</tr>
<tr>
<td>Conditional loss (when high)</td>
<td>($189,964)</td>
</tr>
<tr>
<td>Conditional gain (when low)</td>
<td>$810,036</td>
</tr>
<tr>
<td>Wine list expected gain</td>
<td>$110,036</td>
</tr>
<tr>
<td>Wine list gain in %</td>
<td>2.34%</td>
</tr>
</tbody>
</table>

#### 4.4 Concluding Remarks

Excess demand has puzzled economists for decades. Various explanations involving social externalities, adverse selection, or signaling have been proposed. However, no connection has been made between excess demand, and purchase options for goods with uncertain quality. We bridge these gaps analyzing the case of excess demand in the wine industry. We develop a theoretical framework motivating the use of excess demand to smooth sales across periods with low quality and increase expected profit.

To smooth sales firms can employ a distribution strategy that guarantees a single price, regardless of quality, and provides a purchase option in the next period. By “under pricing” their high quality goods, they create excess demand and a value for their purchase option. We show that excess demand determines secondary market prices, while secondary market prices determine consumer willingness to pay for purchase options. As excess demand increases, consumer willingness to pay for purchase options also increase. The winery’s problem is to choose a wine list price such that it creates enough excess demand and consumer willingness to pay for the option that consumers are willing purchase wine for the guaranteed price when quality is low.
Using a simulated wine list, we illustrate the winery can increase their expected profit over the market clearing levels by employing a wine list with positive excess demand. In a two state example, with market clearing prices of $50 and $40 for high and low quality, a wine list price of $48.10 creates a per unit option price of $8.10. This wine list price generates excess demand when quality is high and clears the market when quality is low, increasing expected profit by 2.34 percent. The winery is better off employing a wine list with positive excess demand than employing a market clearing strategy.

These results are applicable outside the wine industry. Another example previously mentioned may be season tickets for professional sporting teams. Any monopoly that produces non-durable goods with an uncertain quality may benefit from using excess demand and purchase options to smooth sales.

Excess demand may also play a role in determining a firm’s reputation. Specific to the wine industry, consumer willingness to pay for wine is determined in part by the winery’s reputation (Landon and Smith, 1998). If a winery’s reputation positively depends on excess demand, gains in reputation may play a role in a winery’s decision to employ a wine list. Future research could extend the analysis to include endogenous reputation.
Chapter 5

Conclusions

5.1 The Trade Effects of Tobacco Regulation

There are two striking results with important policy implications. First, spatial regulations may not only decrease tobacco imports but also tobacco exports. This suggests spatial regulations have a spillover effect. If a country implements spatial regulations in order to reduce tobacco consumption, and they happen to be an exporting country, our results suggest there will be less tobacco on the world market. This makes a strong case for a unilateral increase in spatial regulations to decrease trade flows of tobacco. Developing countries generally have lower levels of these regulations. If they can be effectively enforced, these regulations offer developing countries a simple policy tool that may reduce tobacco imports. Second, importer marketing regulations appear to increase tobacco imports. Tobacco exporting firms may target those countries with more stringent marketing regulations as it is less costly to compete and earn market share. From a policy maker’s perspective, this presents a number of complicated questions. What are societal impacts in terms of consumption? Does this “crowd out” domestic market share and if so, what are the tax and employment consequences?

5.2 Direct and Indirect Effects of Lease Size on Big Game Quality

The effect of lease size on quality can be decomposed into three effects; a direct effect, an indirect stock effect, and an indirect harvest effects. Using a time-series cross-section from the Mississippi Department of Wildlife and Fisheries with harvest rates and antler measurements for various hunting clubs, we are able to estimate the total effect of lease size on quality. Given data limitations, we are only able to estimate the indirect harvest effect and a combined effect in the
form of the sum of the direct effect and indirect stock effect. If stock levels were available, the indirect stock effect could have been estimated separate from the direct effect. The mechanism considered in our example is driven by externalities. As lease sizes increase, the level of access and excludability of the stock increases. As the stock becomes less of a common pool resource, externalities are increasingly internalized and the resource is used more efficiently. In this case, more efficient use corresponds to fewer deer harvested per acre and a higher average quality of deer harvested. Our results support this hypothesis. Club harvest per acre decreases with lease size. Additionally, lease size has a small but significant effect on the average quality of deer harvested. For all clubs with smaller than average hunting leases, a simulated increase to the average size results in approximately a 4.5 percent increase in the average antler index of deer harvested.

5.3 Excess Demand and Options

To smooth sales firms can employ a distribution strategy that guarantees a single price, regardless of quality, and provides a purchase option in the next period. By “underpricing” their high quality goods, they create excess demand and a value for their purchase option. We show that excess demand determines secondary market prices, while secondary market prices determine consumer willingness to pay for purchase options. As excess demand increases, consumer willingness to pay for purchase options also increase. The firm’s problem is to choose a price such that it creates enough excess demand and consumer willingness to pay for the option that consumers are willing purchase the good for the guaranteed price when quality is low. Using a simulated wine list, we illustrate the winery can increase their expected profit over the market clearing levels by employing a wine list with positive excess demand. In a two state
example, with market clearing prices of $50 and $40 for high and low quality, a wine list price of $48.10 creates a per unit option price of $8.10. This wine list price generates excess demand when quality is high and clears the market when quality is low, increasing expected profit by 2.34 percent. The winery is better off employing a wine list with positive excess demand than employing a market clearing strategy.
References


Appendix 2.1

Assuming markets clear, we have the following condition,

\[ y_i = \sum_{j=1}^{n} y_j \left[ \frac{e^{(r_i, \phi) \beta_i p_i t_{ij}}}{P_j} \right]^{1-\sigma}. \]  \hspace{1cm} (A2.1)

We control for the endogeniety of prices by solving (A2.1) for the scaled prices,

\[ y_i = (\beta_i p_i)^{1-\sigma} \sum_{j=1}^{n} y_j \left[ \frac{e^{(r_i, \phi) t_{ij}}}{P_j} \right]^{1-\sigma} \]

\[ \Rightarrow \beta_i p_i = \left[ y_i \left( \sum_{j=1}^{n} y_j \left[ \frac{e^{(r_i, \phi) t_{ij}}}{P_j} \right]^{1-\sigma} \right)^{1-1} \right]^{\frac{1}{1-\sigma}}. \]  \hspace{1cm} (A2.2)

Let \( y_w = \sum_i y_i \) be world income. Multiply the numerator and denominator of (A1.2) by world income yields,

\[ \beta_i p_i = \left[ \frac{y_i}{y_w} \left( \sum_{j=1}^{n} y_j \left[ \frac{e^{(r_i, \phi) t_{ij}}}{P_j} \right]^{1-\sigma} \right)^{1-1} \right]^{\frac{1}{1-\sigma}}. \]
Appendix 3.1

To sign $\partial \bar{x}/\partial f_i^*$ and $\partial \bar{x}/\partial l_i^*$, define (3) as,

$$G \equiv g(x, E) - \sum_{i=1}^{n} h_i (f_i, l_i^*, r, x) = 0$$

From the implicit function theorem, we know

$$\frac{\partial \bar{x}}{\partial f_i} = -\frac{\partial G/\partial f_i}{\partial G/\partial x} = \frac{\partial h_i/\partial f_i}{\partial g/\partial x - \sum_{i=1}^{n} \partial h_i/\partial x}.$$ 

We assume $\partial h_i/\partial f_i > 0$ and $\partial h_i/\partial x > 0$. The sign of $\partial \bar{x}/\partial f_i$ depends on where we are on the growth curve. If an increase in stock has a large enough positive effect on the growth rate, $\partial \bar{x}/\partial f_i$ may be positive. Otherwise $\partial \bar{x}/\partial f_i$ is negative. The condition is given by,

$$\frac{\partial \bar{x}}{\partial f_i} \begin{cases} 
\geq 0 & \text{if } \frac{\partial g}{\partial x} \geq \sum_{i=1}^{n} \partial h_i/\partial x \\
< 0 & \text{if } \frac{\partial g}{\partial x} < \sum_{i=1}^{n} \partial h_i/\partial x.
\end{cases}$$

Similarly, from the implicit function theorem, we have

$$\frac{\partial \bar{x}}{\partial l_i^*} = -\frac{\partial G/\partial l_i^*}{\partial G/\partial x} = \frac{\partial h_i/\partial l_i^*}{\partial g/\partial x - \sum_{i=1}^{n} \partial h_i/\partial x}.$$ 

The sign of $\partial \bar{x}/\partial l_i^*$ depends on the effect of lease size on harvest and where we are on the growth curve,
\[
\frac{\partial \alpha}{\partial \ell_i^*} \begin{cases}
0 \text{ if } \partial h_i/\partial \ell_i^* \geq 0 \text{ and } \frac{\partial g}{\partial x} \geq \sum_{i=1}^{n} \frac{\partial h_i}{\partial x} \\
0 \text{ if } \partial h_i/\partial \ell_i^* < 0 \text{ and } \frac{\partial g}{\partial x} < \sum_{i=1}^{n} \frac{\partial h_i}{\partial x} \\
< 0 \text{ if } \partial h_i/\partial \ell_i^* < 0 \text{ and } \frac{\partial g}{\partial x} \geq \sum_{i=1}^{n} \frac{\partial h_i}{\partial x} \\
< 0 \text{ if } \partial h_i/\partial \ell_i^* \geq 0 \text{ and } \frac{\partial g}{\partial x} < \sum_{i=1}^{n} \frac{\partial h_i}{\partial x}.
\end{cases}
\]

To sign $\frac{\partial f_i^*}{\partial \ell_i^*}$, define (9),

\[
Z = \frac{\partial U_i}{\partial f_i} = \frac{\partial U_i}{\partial q_i} \frac{\partial q_i}{\partial \alpha^*} + \frac{\partial U_i}{\partial q_i} \frac{\partial q_i}{\partial \alpha} \left( \frac{\partial h_i}{\partial f_i} + \frac{\partial h_i}{\partial \alpha} \frac{\partial \alpha}{\partial f_i} \right) + \frac{\partial U_i}{\partial h_i} \left( \frac{\partial h_i}{\partial f_i} + \frac{\partial h_i}{\partial \alpha} \frac{\partial \alpha}{\partial f_i} \right) = 0.
\]

From the implicit function theorem, we have,

\[
\frac{\partial f_i^*}{\partial \ell_i^*} = -\frac{\partial Z/\partial \ell_i^*}{\partial Z/\partial f_i} = -\frac{\partial U_i^2/\partial f_i \partial \ell_i^*}{\partial U_i^2/\partial f_i^2},
\]

where

\[
\frac{\partial U_i^2}{\partial f_i \partial \ell_i^*} = \frac{\partial U_i^2}{\partial q_i \partial \ell_i^*} \frac{\partial q_i}{\partial \alpha^*} + \frac{\partial U_i^2}{\partial q_i \partial \alpha^*} \frac{\partial q_i}{\partial \ell_i^*} + \frac{\partial U_i^2}{\partial q_i \partial \alpha} \frac{\partial q_i}{\partial \ell_i^*} \frac{\partial \alpha}{\partial f_i} \frac{\partial h_i}{\partial f_i} \frac{\partial h_i}{\partial \alpha} \frac{\partial \alpha}{\partial f_i} \frac{\partial \alpha}{\partial \ell_i^*} + \frac{\partial U_i^2}{\partial q_i \partial \alpha} \frac{\partial q_i}{\partial \ell_i^*} \frac{\partial \alpha}{\partial f_i} \frac{\partial h_i}{\partial f_i} \frac{\partial h_i}{\partial \alpha} \frac{\partial \alpha}{\partial f_i} \frac{\partial \alpha}{\partial \ell_i^*} + \frac{\partial U_i^2}{\partial q_i \partial \alpha} \frac{\partial q_i}{\partial \ell_i^*} \frac{\partial \alpha}{\partial f_i} \frac{\partial h_i}{\partial f_i} \frac{\partial h_i}{\partial \alpha} \frac{\partial \alpha}{\partial f_i} \frac{\partial \alpha}{\partial \ell_i^*} \frac{\partial \alpha}{\partial \ell_i^*} + \frac{\partial U_i^2}{\partial q_i \partial \alpha} \frac{\partial q_i}{\partial \ell_i^*} \frac{\partial \alpha}{\partial f_i} \frac{\partial h_i}{\partial f_i} \frac{\partial h_i}{\partial \alpha} \frac{\partial \alpha}{\partial f_i} \frac{\partial \alpha}{\partial \ell_i^*} \frac{\partial \alpha}{\partial \ell_i^*} + \frac{\partial U_i^2}{\partial q_i \partial \alpha} \frac{\partial q_i}{\partial \ell_i^*} \frac{\partial \alpha}{\partial f_i} \frac{\partial h_i}{\partial f_i} \frac{\partial h_i}{\partial \alpha} \frac{\partial \alpha}{\partial f_i} \frac{\partial \alpha}{\partial \ell_i^*} \frac{\partial \alpha}{\partial \ell_i^*} + \frac{\partial U_i^2}{\partial q_i \partial \alpha} \frac{\partial q_i}{\partial \ell_i^*} \frac{\partial \alpha}{\partial f_i} \frac{\partial h_i}{\partial f_i} \frac{\partial h_i}{\partial \alpha} \frac{\partial \alpha}{\partial f_i} \frac{\partial \alpha}{\partial \ell_i^*} \frac{\partial \alpha}{\partial \ell_i^*} + \frac{\partial U_i^2}{\partial q_i \partial \alpha} \frac{\partial q_i}{\partial \ell_i^*} \frac{\partial \alpha}{\partial f_i} \frac{\partial h_i}{\partial f_i} \frac{\partial h_i}{\partial \alpha} \frac{\partial \alpha}{\partial f_i} \frac{\partial \alpha}{\partial \ell_i^*} \frac{\partial \alpha}{\partial \ell_i^*}
\]

and

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Without imposing specific structures to the utility function, harvest function, and quality function we cannot make any inference on the sign of $\frac{\partial f^*}{\partial l^i}$. If the marginal utility of effort is increasing in lease size, $\frac{\partial U^2}{\partial f_i^2}$ would be positive. If the marginal utility of effort is increasing at a decreasing rate, $\frac{\partial U^2}{\partial f_i^2}$ would be negative. Under such conditions, $\frac{\partial f^*}{\partial l^i}$ would be positive. The possible sign of $\frac{\partial f^*}{\partial l^i}$ is characterized by,

$$
\begin{align*}
\frac{\partial f^*}{\partial l^i} &\geq 0 \text{ if } \frac{\partial U^2}{\partial f_i^2} \partial l^i \geq 0 \text{ and } \frac{\partial U^2}{\partial f_i^2} \partial f_i^2 \leq 0 \\
\frac{\partial f^*}{\partial l^i} &< 0 \text{ if } \frac{\partial U^2}{\partial f_i^2} \partial l^i \geq 0 \text{ and } \frac{\partial U^2}{\partial f_i^2} \partial f_i^2 > 0 \\
\frac{\partial f^*}{\partial l^i} &\geq 0 \text{ if } \frac{\partial U^2}{\partial f_i^2} \partial l^i < 0 \text{ and } \frac{\partial U^2}{\partial f_i^2} \partial f_i^2 \geq 0 \\
\frac{\partial f^*}{\partial l^i} &< 0 \text{ if } \frac{\partial U^2}{\partial f_i^2} \partial l^i < 0 \text{ and } \frac{\partial U^2}{\partial f_i^2} \partial f_i^2 < 0.
\end{align*}
$$
Appendix 3.2

Consider the following equation,

$$y_{it} = Y_{it} \gamma + X_{1it} \beta + \mu_i + \nu_{it} = Z_{it} \delta + \mu_i + \nu_{it}$$  \hfill (A3.1)

where $y_{it}$ is the dependant variable, $Y_{it}$ is a $1 \times k_1$ vector of observations on $k_1$ endogenous covariates that may be correlated with $\nu_{it}$, $X_{1it}$ is a $1 \times k_2$ vector of observations on the $k_2$ exogenous variables, $Z_{it} = [Y_{it} \ X_{1it}]$, $X_{it} = [X_{1it} \ X_{2it}]$, $X_{2it}$ is a $1 \times k_3$ vector of observations on the $k_3$ instruments such that $k_3 \geq k_1$, and $\gamma, \beta, \delta$ are vectors of coefficients. Given an unbalanced panel, let $T_i$ be the number of observation on panel $i$, $n$ be the number of panels, and $N$ be the total number of observations.

The within and between transformations of (A3.1) are,

$$\tilde{y}_{it} = \tilde{Z}_{it} \delta + \tilde{\nu}_{it}$$

and

$$\bar{y}_i = \bar{Z}_i \delta + \mu_i + \bar{\nu}_i$$

where $\tilde{w}_{it} = w_{it} - \frac{1}{n} \sum_{t=1}^{T_i} w_{it} + \frac{1}{N} \sum_{i=1}^{n} \sum_{t=1}^{T_i} w_{it} \ \forall \ w \in \{y, Z, \nu\}$ and $\bar{w}_i = \frac{1}{T_i} \sum_{t=1}^{T_i} w_{it} \ \forall \ w \in \{y, Z, \nu\}$.

The combined residuals for the within estimator are $u_{it}^w = \tilde{y}_{it} - \tilde{Z}_{it} \delta^w$. Let $\tilde{u}_i$ be the within transformed residuals. Following Swamy and Arora (1972), a consistent estimate of the idiosyncratic error component is given by $\hat{\sigma}_v = \frac{\sum_{i=1}^{n} \sum_{t=1}^{T_i} \hat{u}_{it}^2}{N - n - K + 1}$. The combined residuals from the between estimator are $u_{it}^b = \bar{y}_{it} - \bar{Z}_i \delta^w$. Let $\bar{u}_i$ be the between transformed residuals. The
individual error component can be estimated consistently by
\[
\hat{\sigma}^2 = \frac{\sum_{i=1}^{n} \sum_{r=1}^{T_i} \tilde{u}_{it}^2 - (n - K) \hat{\sigma}_v}{N - r},
\]
where \( r = \text{trace} \left( \left( \tilde{Z}_i'\tilde{Z}_i \right)^{-1} \tilde{Z}_i' \mu_i' \mu_i \tilde{Z}_i \right) \), \( Z_\mu = \text{diag} \left( i_t, i_t' \right) \), and \( i_t \) is a \( T_t \times 1 \) vector of ones. Finally, the feasible GLS transformation is \( w^* = w_{it} - \hat{\theta}_i \tilde{w}_i \) where
\[
\hat{\theta}_i = 1 - \left( \frac{\hat{\sigma}_v^2}{T_i \hat{\sigma}_\mu^2 + \hat{\sigma}_v^2} \right)^{-\frac{1}{2}}
\]
and
\[
\tilde{w}_i = \frac{1}{T_i} \sum_{r=1}^{T_i} w_{it} \quad \forall \ w \in \{ y, Z, X, v \}.
\]
The generalized two-stage least squares estimates are given by the instrumental variable regression of \( y_{it}^* \) on \( Z_{it}^* \) with instruments \( X_{it}^* \),
\[
\hat{\delta}_{G2SLS} = \left( X_{it}^* Z_{it}^* \right)^{-1} X_{it}^* y_{it}^*.
\]
Appendix 4.1

Proof for proposition 1:

Given \( D^k \left( P^* \right) \geq Q \) for \( k = h, l \), the wine list profit is \( \pi^* = P^*Q - C \) and we have

\[
\frac{\pi^* + C}{Q} = P^*.
\]

Given \( \pi = P^*Q - C \), we have

\[
\frac{\pi + C}{Q} = P^*.
\]

Using the fact that \( P \leq P^* \), we know \( \frac{\pi + C}{Q} \leq \frac{\pi^* + C}{Q} \), and it immediately follows that \( \pi \leq \pi^* \).

From the definition of the certainty equivalent,

\[
\alpha \pi^h + (1-\alpha) \pi^l = \pi.
\]

Hence, we have

\[
\alpha W[\pi^h] + (1-\alpha) W[\pi^l] \leq W[\pi^*].
\]

Q.E.D.