CONSUMER WILLINGNESS TO PAY FOR LOCAL VEGETABLES GROWN IN A CONTROLLED ENVIRONMENT: THE CASE OF LETTUCE

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ABSTRACT

A willingness to pay study for lettuce has been conducted to determine potential price advantages for year-round local vegetables grown in Controlled Environment Agriculture (CEA) production systems. The specific objective of the study was to measure differences in consumer willingness to pay for lettuce with different origins (New York State vs. Out-of-State) and grown under different production systems (CEA vs. field-grown). In addition, the study examines whether further information about origin and production system affects consumer willingness to pay. In a lab setting (Cornell Lab for Experimental Economics and Decision Research), we manipulated information about the different production systems and origins of lettuce and then we tested for consumers' WTP for loose leaf lettuce. The Becker-DeGroot-Marschak (BDM) auction was used to elicit consumer WTP. Results suggest that consumers are willing to pay a price premium of $0.30 for local lettuce and they are indifferent between the production systems. Also, results suggest that information about the production system/origin does not affect consumer WTP. The results support the hypothesis that locally-grown vegetables have the potential to become a commercial success in the New York State. Lettuce producers and channel members can use the estimated price premium as a reference when making their production, pricing, or promotion decisions.

BIOGRAPHICAL SKETCH

Irin Ferdous Nishi was born in Chittagong, Bangladesh in the year of 1986. She received her Bachelor of Business Studies degree in Marketing in 2008 and Masters of Business Studies degree in Marketing in 2009 from University of Dhaka, Bangladesh. She earned a Master of Science in Agricultural and Resource Economics in 2014 from Tuskegee University, USA. Then, she worked as a Research Assistant in the Department Applied Economics and Management at Cornell University, USA from December 2014 to August 2015. She joined the Master program at Charles H. Dyson School of Applied Economics and Management in August 2015 and received her Masters of Science in August 2017. During her graduate study in Cornell University, she focused on the research of Food and Agricultural economics.

To my family

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CHAPTER 1: INTRODUCTION

New food trends are emerging as the result of changing consumer preferences. These trends are, in part, driven by consumers' changing preferences for taste, nutrition, availability, seasonality, distance traveled from farm to table, pesticide use, and environmentally sustainable farm practices. Given the complex nature of consumer demand in the global marketplace, the need for agricultural growth and modernization is crucial. If producers are to succeed in this dynamic environment, they must be able to both quickly identify changing demand patterns as well as adapt their agricultural practices.

Two increasingly important product attributes for consumers are *locally-grown* and *year-round availability*. According to The United States Department of Agriculture (USDA), "Local food is defined as the direct or intermediated marketing of food to consumers that is produced and distributed in a limited geographic area." Though there is no pre-determined distance, "local" usually refers to a set number of miles from a center point or state/local boundaries.

The primary agricultural policy tool in the United States is 'Farm Bill', which enables USDA to further expand markets for agricultural products, strengthen conservation efforts, and create new opportunities for local and regional food systems (USDA, 2014). The USDA, together with the United States Congress, periodically updates the Farm Bill to reflect changes in consumer preferences as well as political will. In response to growing demand for locally-grown fruits and vegetables, the most recent, 2014, Farm Bill provides $30 million annually to the "Farmers Market and Local Food Promotion Program" and allocates $65 million to develop local and regional

food systems through Value Added Product Market Development grants (USDA, 2014). In the last nine years, demand for local food has expanded from $1 billion to $7 billion (ICP, 2015). Despite the increasing demand for local fruits and vegetables, production seasonality makes it impossible for local producers to satiate the year-round demand. For instance, consumers in the northern regions of the United States have a hard time finding locally-grown vegetables in the late fall and winter. Despite consumer interest in local foods, more than 95% of the lettuce, tomatoes, and spinach consumed in New York State (NYS) is supplied by other states or imported (Albright, 2008). U.S. fruit and vegetable exports totaled $6 billion in 2015 while imports were $18 billion, resulting in a gap of $12 billion (Johnson, 2016). Most of the produce imported in the United States originates from Mexico, Canada, Chile, or the European Union. Within the U.S., fresh fruit and vegetable production is concentrated in California, Florida, and Washington. In 2015, California produced more than 51% of the nation's fresh market vegetables by weight and 58% by farm value (USDA, 2015). Due to its optimal climate and soil conditions, California is the primary center of fruit and vegetable production (USDA, 2014). However, recent environmental issues such as the prolonged drought from 2007-2014 (Wallender, 2015) and rainy winters have affected production in California. Also, fresh produce imported from other states tends to loose quality when transported large distances, and also energy requirements for long distance transport can be significant and costly. These issues, together with shrinkage and waste, have compelled food researchers and developers to advocate for increased spatial diversification of fruit and vegetable production.

Greenhouses with controllable temperature and supplemental light allow for

year-round vegetable production by mitigating the effects of weather. Greenhouses have been shown to enhance product quality, increase production yields and enable growers to cultivate their crop over a longer period. Controlled Environment Agriculture (CEA) is an advanced and intensive form of agriculture where plants are grown within controlled environments to optimize agricultural practices (Albright, 1996). People often use Greenhouse (GH) as a synonym for Controlled Environment Agriculture (CEA); however, Greenhouse production is a generic term that generally implies plants growing within a relatively permanent structure equipped with environmental modification (typically a minimum of heating and ventilating capabilities). Controlled Environment Agriculture (CEA), on the other hand, refers to more sophisticated growing systems involving mechanization and coordinated environmental control (Albright, 1996). With a focus on plant quality, seasonality, and quantity, CEA is designed to provide an integrated system to optimize production. As consumers are not very familiar with the term CEA and are usually not concerned about the difference between two systems, we assume that these two terms (CEA and GH) are synonymous. CEA technology is designed to increase production, productivity, and profitability of the produce sector. This technology has the potential to overcome the limitations of traditional open-field vegetable production systems such as short harvesting periods, crop failure due to adverse climatic conditions, less than optimum production, and seasonality of production (St. Martin et al., 2008).

The CEA industry specializing in growing vegetables in the United States is growing rapidly. CEA greenhouse systems that include supplemental light, heating, and environmental controls can produce higher yields per unit land area compared to

outdoor production due to the intensive cultivation methods described above. For example, in 2012, there were 2,227 acres of greenhouse vegetable produced in the U.S. with a wholesale value of $624 million (USDA-NASS, 2014). For field vegetables (including for processed and fresh use), $16.9 billion in wholesale value was produced on 4,492,086 acres. Therefore, production value (revenue) per acre was $280,000 for greenhouse vegetables compared to $3,762 for field vegetables (USDA, 2012).

The prevalence of CEA agriculture is increasing in northern states, particularly NYS. For example, in 2012, there were 435 operations in NYS that grew greenhouse (Census of Agriculture, 2014). They used 114 acres of covered area to produce an annual wholesale value of $27.4 million, a 54% increase from 2007 (Census of Agriculture, 2014). NYS ranks second nationally in greenhouse production and ranks fifth for the value of fresh market field vegetable production, with $450 million annual wholesale value (Census of Agriculture, 2014).

Locally grown vegetables from NYS greenhouses represent a valuable opportunity as consumer preferences continue to shift towards locally grown produce. By 2020, the U.S. market for CEA vegetables is projected to grow from $3 billion to $4 billion annually (NYS Government, 2013). Meanwhile, the NYS floriculture sector which is comprised of 1,124 production operations with 550 acres of greenhouse area producing $211 million annually in wholesale value (Census of Agriculture, 2014) continues declining. Many floricultural producers are beginning to look at greenhouse vegetables as a new market opportunity and a way to keep their greenhouse operation viable.

CEA greenhouse facilities often struggle to compete with field production

because of their high initial investment costs. However, the costs of CEA technologies for CEA greenhouse production such as lighting, seed development, and control systems have declined over time (ICP, 2015). Also, CEA technologies are able to sustain higher yields in comparison to field production. According to the Cornell CEA research group, CEA production can exceed the production of field vegetables per acre by 10 to 20 times per unit of area making the cost per plant comparable between systems (Albright & Langhans, 1996).

Given the important role CEA greenhouses will play in supporting the growth of local foods, we focus on the case of lettuce to examine consumer willingness to pay for local food produced under alternative production methods (field vs. CEA). Lettuce is a important product to study because it is one of the most commonly grown CEA vegetables in the U.S., it is a crop with great potential for year-round production and it is consumed all year. Lettuce is also well-suited for northern latitudes, given it requires lower light and lower temperature than fruiting crops such as tomato or cucumber. Also, as a perishable crop, it gives a competitive advantage to local growers by enabling them to pick and deliver fresh produce daily. In addition, consumer demand for leafy greens has increased dramatically in recent years as consumers desire more healthy and diverse foods in their diets (USDA, 2013). The value of U.S. lettuce production in 2015 was nearly $2.9 billion, making lettuce the leading vegetable crop in terms of value (AGMRC, 2017). In 2015, the U.S. produced 8,087 million pounds of lettuce with 487 million pounds imported and 261 million pounds exported (USDA, 2016). Lettuce ranked second only to potato with annual consumption of 24.5 pounds per person in 2015 (AGMRC, 2017). In the U.S., lettuce is produced year-round and in many states.

California dominates U.S. production by producing 71% of all head lettuce in 2013, followed by Arizona producing nearly 29% (AGMRC, 2017). Given the concentration of current production, producing lettuce in a greenhouse where local climate does not permit year-round field production represents an attractive business opportunity for growers interested in catering to local food markets.

Consumers often prefer local foods because for their freshness, perceived nutritional properties, decreased distances traveled (which reduce transportation costs and greenhouse gas emissions), and because they want to support their local economies (King et al., 2010). Local lettuce grown in greenhouses in states like New York can meet the demand for local foods. For growers, this is an opportunity to obtain price premiums expected for locally and regionally-grown year-round vegetables. However, it is not always easy to achieve consumer acceptance of new technologies such as hydroponic foods, genetically modified (GM) crops, vertical farming products, and nanotechnology (Coyle and Ellison, 2017; Dannenberg, 2009; Siegrist et al., 2007; Frewer et al., 2011).

The first contribution of this study is to evaluate consumer willingness to pay (WTP) for lettuce grown in different origins (California vs. NYS) under two different production systems (CEA-grown vs. field-grown). Moreover, because consumers are unaware of the CEA technology, it is not known how consumers might differentially value CEA-grown lettuce. Thus, a second contribution of this study is to understand the value of providing information about the characteristics of field-grown and CEA-grown production systems. We assess how consumer perceptions change when they are provided more information regarding production systems and origins. Therefore, our

results allow us to determine the potential price advantages for year-round local vegetables grown in Controlled Environment Agriculture (CEA) which could assess the development of a NYS CEA-grown lettuce market.

The specific objective of the study is to measure differences in consumer willingness to pay for lettuce with different origins (New York State vs. Out-of-State), different production systems (CEA vs. field-grown), and to examine whether further information about origin and production system affect consumer willingness to pay. If consumers value local lettuce produced year-round, this means that opportunities for CEA production in the context of local food systems. This can yield benefits for both consumers and producers. Consumers will be able to enjoy more purchasing choices and local producers may be able to benefit from year-round demand if they make the necessary investments in CEA production.

CHAPTER 2: LITERATURE REVIEW

Researchers have used contingent valuation (CV), choice experiments (CE), and experimental auctions (EA) to elicit consumer preferences on various attributes for multiple products, including food (Huffman et al., 1996; Hossain et al., 2003; Loureiro and Umberger 2005; Moser et al., 2011). Hypothetical methods (personal interviews as well as online, mail and telephone surveys) were mostly used by the researchers because of their simplicity and ease of use. However, several studies claimed that hypothetical WTP is substantially higher than real world WTP (Botelho and Pinto, 2002; Neill, 1994; Wertenbroch and Skiera, 2002). A common method to estimate consumers' WTP is Contingent Valuation (CV), where consumers assign a value in a hypothetical purchasing situation indicating how much they would be willing to pay for a given product. However, contingent valuation methods violate the incentive-compatibility criterion needed for (rational) participants to reveal their true WTP. Wertenbroch and Skiera, (2002) argued that consumer responses in contingent valuation were merely hypothetical as there was no cost to participants for not truthfully stating their WTP. Their hypothesis was supported when (Lusk et al., 2004) found that consumers were less truthful when spending hypothetically money compared to real money. Another method frequently used to assess willingness to pay is choice experiments (Adamowicz et al., 1998). In a choice experiment, individuals are asked to choose their preferred alternative from a given choice set. Yue & Tong (2009) compared a hypothetical and non-hypothetical choice experiment, with real economic incentives, and found that the bias was minimized in hypothetical experiments when actual products were used as part of the study.

A method that is gaining popularity in empirical studies of consumer behavior is 'Experimental Auctions' (EA). Researchers have used experimental auctions to estimate consumer demand for food products in different extents, including: non-bovine somatotropin milk (Fox et al. 1994); reduced insecticide use in apples (Roosen et al. 1998); beef packaging (Huffman et al. 1996); and nongenetically modified corn chips (Lusk et al. 2001). Experimental Auctions are becoming more popular in nonmarket valuation because of their ability to elicit consumers' true WTP for product attibutes. It differs from contingent valuation as participants' responsibility and real money is involved in this method (Grunert et al., 2009). Researchers have shown that participants are more motivated to reveal their true WTP for products in an experimental setting than in survey methods as real products and real money are exchanged (Fox et al., 1998; Cummings et al., 1995; List and Shogren, 1998).

Because of these advantages, Experimental Auctions are gaining acceptance as a valuable tool in market research. Several studies have used EA to investigate the impact of labeling on WTP for food attributes (Dickinson and Bailey, 2002; Hoffman et al., 1993; Umberger et al., 2002). The Becker-DeGroot-Marschak auction (BDM) is a popular experinmental auction format used at point-of-purchase locations and widely applied to elicit consumers' perception of food (Shi et al., 2015; Carrigan and Rousu, 2008; Silva et al., 2007; Rozan et al., 2004). Becker et al. (1964) introduced the BDM mechanism as a way to induce individuals to truthfully reveal their preference for products. In the BDM auction procedure, subjects individually submit sealed bids for a good. Next, a random number or price is drawn from a pre-specified distribution. Individuals whose bid is greater than the randomly drawn price "win" the auction and

can purchase the good at the randomly drawn price (Becker et al., 1964). A number of studies have shown that BDM auctions are more reliable than alternative methods, as they provide an incentive for participants to reveal their true perceived value through their bid (Becker, DeGroot, & Marschak, 1964; Lusk & Shogren, 2007). Research by Wertenbroch and Skiera (2002) and Voelckner (2006) indicated that the BDM mechanism was suitable for measuring situation-specific, individual WTP as it enabled researchers to elicit WTP in an incentive-compatible point-of-purchase situation. Wertenbroch and Skiera (2002) also indicated that buyers as well as the non-buyers were extremely satisfied with the outcome of the BDM experiment. This result indicates that BDM does not suffer from the overbidding or underbidding bias of survey methods and choice experiments.

Studies have shown that consumer preference for local foods is increasing, in part because consumers perceive local foods to have superior attributes such as freshness, nutrition, reduced environmental impacts, and provide increased benefits to local economies (Brown, 2003; Loureiro and Hine, 2001). Consumers are becoming more concerned about not only quality and cost of foods, but also in how, where, and by whom food is produced and distributed. Martinez (2010) reviewed studies on WTP for a wide range of locally produced food in U.S. He found that differences in consumer WTP for various food products could be attributed to product perishability, base price, and regional differences in attitudes toward local foods. Loureiro and Hine (2002) showed that Colorado consumers were willing to pay a higher premium for local than for organic or ‘‘GMO-free’’ potatoes. Midwestern consumers also valued locally grown strawberries more than strawberries grown in any other place because of attributes like

freshness, support for small farms and the local economy, and environmental sustainability (Darby et al., 2008). Attributes for local foods have also been intensively studied, including quality and freshness (Brown, 2003), nutritional benefits (Loureiro and Hine, 2002), environmental benefits (Brown, 2003; Zepeda and Leviten-Reid, 2004), and impacts on local farmers (Carpio and Isengildina-Massa, 2009). For instance, Carpio and Isengildina-Massa (2009) conducted an analysis of socio-demographic characteristics influencing willingness to pay for locally-grown produce and animal products in South Carolina. The results revealed an average price premium of 27% and 23% for South Carolina's produce and animal products, respectively. Additionally, their results show that willingness to pay for state-grown produce have a direct positive correlation with both age and income.

Although a large body of work exists on consumer preferences and WTP for locally-grown food, limited studies have specifically focused on Greenhouse or Controlled Environment Agriculture vegetables. At the time of this article, there was only one study by Coyle and Ellison (2017) which focuses on the impacts of providing information about CEA production on consumer WTP. The study investigated consumers' acceptance of vertical farming as a new production technology relative to greenhouse and field production systems. The authors found that although information improved consumers' knowledge of production system, the WTP for vertically-farmed lettuce was similar to that of greenhouse or field-grown lettuce.

Several studies have focused on the economic aspects of CEA vegetables. For example, Ilaslan et al. (2002) studied the economic viability of a new CEA system producing hydroponic lettuce and found that freshness, price, appearance and

convenience are the most important factors to consumers when purchasing lettuce. Narine et al. (2014) examined consumers' willingness to pay (WTP) for greenhouse-hydroponic (GH) tomatoes when marketed as a differentiated commodity and found that without providing any supporting public educational programs, the differentiation may not be a practical solution for farmers. Padilla et al. (2007) evaluated consumers' appreciation of conventionally grown tomatoes and tomatoes grown in soilless culture and found that taste and satisfaction were the main determinants of food choice in Morocco and Turkey. Huang et al. (1999) reported that family health status and household income were the most significant factors affecting consumers WTP for hydroponics vegetables in Taiwan. Huang et al. (2002) also showed that there was a demand for hydroponic cucumbers and tomatoes in Nashville, U.S., and the nutritional and physical qualities should be highlighted to market hydroponics vegetables. Viriyakul (2013) studied the factors affecting the market mix of vegetables grown in hydroponics and showed that the size of family and their income were important factors affecting the demand of hydroponics vegetable.

Identifying the attributes that are most valuable to consumers can shed light on how to market CEA vegetables. To our knowledge, no studies have been conducted to examine consumer willingness to pay (WTP) for NYS and CEA grown lettuce. Therefore, our study contributes to the literature by filling this gap. In addition, this study contributes to the existing literature by examining the effect of sharing information on consumer willingness to pay for CEA grown produce. The economic laboratory experiment presented here explores consumer response and willingness to pay for NYS and CEA grown lettuce based upon characteristics of origin, production

system, and information. Our research uses a BDM auction to analyze critical factors influencing the willingness to pay of consumers for locally CEA grown lettuce grown in NYS. The results can inform the development of appropriate marketing strategies for this new category.

CHAPTER 3: METHODOLOGY

3.1 Experiment Design

We ran an economic experiment to examine consumer Willingness to Pay (WTP) for four lettuce categories: Lettuce A (CEA-grown in New York State), Lettuce B (Field-grown in New York State), Lettuce C (CEA-grown Out-of-State), and Lettuce D (Field-grown Out-of State). Lettuce is an excellent case because it is widely grown in NYS during summer for local consumption and it is increasingly being grown in greenhouses in the northeast. Our experimental design considers two product attributes, including production system (CEA and field) and origin (local and non-local); and two alternative information treatments. In order to ensure similar lettuce quality across experimental sessions, the product was kept under appropriate controlled-atmosphere conditions. Other product attributes such as lettuce color, quality, and freshness were not included in the design because the lettuce was of the same quality. When purchasing the lettuce for the experimental sessions, we carefully compared lettuce color, quality, and freshness to ensure quality consistence across experimental treatments. In fact, subjects stated that they were unable to distinguish between lettuces presented in the experiments.

We collected WTP information from subjects who were exposed to one of two treatments. Each treatment provided different information regarding the production systems and origins of the four lettuce categories. We ran three experimental sessions for each of the two treatments for a total of six sessions. In the first treatment, subjects were informed only about the production system (CEA or field) and origin (NYS or out-of-state) of the lettuce. In this treatment, subjects revealed their WTP for the different types of lettuce based only on

the information provided about the product (e.g., Greenhouse-grown in New York State, Field-grown in New York State). In the second treatment, subjects received detailed information about the four types of lettuce. Specifically, for each lettuce type subjects received information on: 1) how many months lettuce is available through the year; 2) miles traveled from production location to consumption location; and 3) number of jobs created and the seasonality of these jobs. Information shared with the consumers in the first treatment (no information) and in the second treatment (information) is listed in the appendix.

3.2 Auction Procedure

A BDM auction was conducted to elicit subject maximum WTP for the four lettuce categories. In a laboratory setting (Cornell Lab for Experimental Economics and Decision Research), we manipulated information about the different production systems and origins of the lettuce products presented to experiment participants. We restricted our study to nonstudent subjects with a minimum age of 18 years and also to regular buyers of lettuce. Subjects were seated randomly at individual computer terminals with privacy shields, were informed that all decisions they made would be kept strictly confidential. A maximum of 24 computer terminals were available per session, and the number of subjects in each of the six sessions ranged from 15 to 24.

At the beginning of the each auction, subjects received a consent form and an instruction sheet with detailed auction procedure. Subjects were given a brief introduction of the experiment which included the rules of the experiment and the amount of money they would earn. Then they were asked if they have any question and to sign the consent form. The auction procedure involved following steps:

1. Each session began with two practice rounds to demonstrate how the WTP auctions would be conducted. In the practice round, subjects submitted bids for a dollar bill and a chocolate bar so they would become familiar with the bidding process we would be using for the auctions.
2. Subjects were endowed with $15 in cash and informed that the cash could be used to pay for the lettuce if they won the auction or for them to keep if they did not win. Then subjects were given information regarding the production systems and origins of the four lettuce categories (CEA-NYS, Field-NYS, CEA-Out-of-State, and Field-Out-of-State) used in the experiment. Lab assistants displayed approximately 8 ounces of each of the four lettuce categories so that subjects could closely examine each product. Subjects were then asked to place bids for 8 ounces of each lettuce category in the auction.
3. Subjects were informed that only one of the lettuce categories would result in an actual transaction, although they submitted bids for the four categories. After participants placed their bids, one lettuce category was randomly drawn to determine which one was actually auctioned. Therefore, participants only had the opportunity to "win" one type of lettuce.
4. After the lettuce category had been determined, a random market price was drawn from $0 to $5 with increasing scale of $0.25. If a subject's bid for the selected lettuce was higher than the randomly drawn price, the subject would "win" the auction and purchased 8 ounces of lettuce at the randomly selected market price, which was deducted from their endowment. If a subject's bid for the selected

lettuce was lower than the randomly drawn price, the subject did not "win" the auction and therefore did not purchase the lettuce.

5. They also completed an exit survey at the end of the experiment regarding demographic and behavioral characteristics.

3.3 Data and Empirical Model

We collected 500 observations from 125 non-student participants in the lettuce experiment sessions. Some of the data were not included in the analysis because of one or more missing values. 464 observations from 116 participants were included in the analysis.

To estimate the influence of origin and production system under alternative information treatments, we employ a Random Effect model to account for the panel nature of the data. The latent value of WTP for category j in information treatment t for individual i, denoted as WTP^*_{jti}, is expressed as a function of the three indicator variable *CEA*, *NYS*, and *INFO* and the subjects' demographic characteristics, X_i. Because each subject responded to all four lettuce types, the random components ν_i is an individual-specific disturbance for subject i; and ε_{jti} is the error term for consumer i' which is assumed to follow a normal distribution with mean zero and standard deviation σ.

In Equation (1) we assume a linear functional form for the WTP equation. Equation (2) show the relationship between the latent and the observed dependent variable *WTP* in the Tobit, nonlinear model.

(1) $$WTP^*_{jti} = \alpha + \gamma_1 CEA + \gamma_2 NYS + \gamma_3 INFO + \theta X_i + \nu_i + \varepsilon_{jti}$$

(2) $$WTP_{jti} = max\{0, WTP^*_{jti}\}$$

In the model specified above, α is the average bid for 8 ounces of the Field-Out-of-State-grown lettuce when no additional information about origin and production system is revealed. Indicator variables *CEA*, *NYS*, and *INFO* refer to the production system (1 if lettuce is CEA-grown, 0 if field-grown), origin (1 if lettuce is NYS-grown 0, if out-of-state-grown) and information treatment (1 if additional detailed information is given, 0 otherwise), respectively. Indicator variables are often used to account for qualitative factors in econometric models. Indicator variables or dummy variables take just two values, usually one or zero, to indicate the presence or absence of a characteristic or to indicate whether a condition is true or false (Hill, 2011). As multiple dummy variables are present in this model, it is important for proper interpretation to write out the regression function, E(WTP), for each indicator variable combination:

$$E(WTP) = \begin{cases} \alpha + \theta X_i & \text{Field-Out-of-State– No info} \\ (\alpha + \gamma_1) + \theta X_i & \text{CEA-Out-of-State- No info} \\ (\alpha + \gamma_2) + \theta X_i & \text{Field-NYS- No info} \\ (\alpha + \gamma_3) + \theta X_i & \text{Field-Out-of-State– Info} \end{cases}$$

In this specification, Field- Out-of-State– No info are the reference group, because this is the group defined when all indicator variables take the value zero, in this case *CEA*=0, *NYS*=0, and *INFO*=0. The parameter γ_1 measures the effect of *CEA*, relative to the reference group; the parameter γ_2 measures the effect of being local, and the parameter γ_3 measures the effect of providing more information. X_i is a vector of independent variables including demographics and attitude information..

The model is then expanded by including cross-effects of the lettuce characteristics. The Equation (3) then becomes:

(1) $WTP_{jti}^{*} = \alpha + \gamma_1 CEA + \gamma_2 NYS + \gamma_3 INFO + \gamma_4 CEAXINFO + \gamma_5 CEAXNYS + \gamma_6 NYSXINFO + \gamma_7 \theta X_i + \nu_i + \varepsilon_{jti}$

Here, the parameter γ_4 measures the cross effect of providing more information and being CEA, γ_5 measures the cross effect of being CEA and local, and γ_6 measures the cross effect of being local and receiving more information.

CHAPTER 4: RESULTS

4.1 Characteristics of the sample

The descriptive statistics of the sample are presented in Table 1. It presents the summary of the demographic variables based on the responses to the questions asked in the survey. Results show that the majority of the subjects in our sample were female (76%) and aged between 25 to 54 years (66%). 19% of the participants had 2 year degree and 81% had bachelor degree or higher. Annual income ranged between $40,000 and $69,999 for 51% of the participants. "Frequency" asked about how often participants eat lettuce and 89% of the respondents reported they eat lettuce at least 1-3 times a week. These results indicate that the sample of the participants were representative of buyers who were regular fresh lettuce consumers. In the questionnaire, we also asked participants how often they check the origin and production system of lettuce using a Likert scale with 1 being always and 5 being never. 75% of the participants stated they check origin and 53% stated they check production system at some extent when purchasing lettuce indicating that consumers are interested to know where and how their food is being produced. Results also showed that 78% of the participants were a primary shopper in their households.

4.2 Average WTP for lettuce

In this section, we present the average WTP of consumers for four lettuce categories: Lettuce A (CEA- NYS), Lettuce B (Field- NYS), Lettuce C (CEA- Out-of-State), and Lettuce D (Field- Out-of-State) and for different information treatment (Table 2). The table shows that averaging the bids for per 8 ounces lettuce results in a WTP of $1.69, which is comparable to retail prices in local markets. The mean bid for

the Lettuce A (CEA-NYS) and the mean bid for Lettuce B (Field-NYS) had the highest bids ($1.84) while the average bid of Lettuce D (Field- Out-of-State) had the lowest ($1.52).

There is a clear difference between the NYS and Out-of-State categories as both NYS categories have higher bids. When we compared the two production systems, we saw that participants were willing to pay the same price for field and CEA grown lettuce when purchasing local (NYS) but willing to pay slightly less price for field grown lettuce when purchasing Out-of-State. In addition, table 2 shows participant willingness to pay for each category under two different information treatments. We found that Lettuce A (CEA-NYS) and Lettuce B (Field-NYS) have higher bids under 'with information' treatment with values ($1.96) and ($1.89) respectively. The WTP for Lettuce C (CEA-Out-of-State) and Lettuce D (Field-Out-of-State), on the other hand, follows exactly the opposite trend. Consumers were willing to pay less under 'with information' treatment compared to the 'no information' for Lettuce C and Lettuce D.

We performed a t-test to see if the WTP between those categories were significantly different. Our results show that there was a significant difference between the WTP for Lettuce A (CEA- NYS) and Lettuce C (CEA-Out-of-State), and Lettuce A (CEA- NYS) and Lettuce D (Field-Out-of-State). Also, significant difference was found between Lettuce B (Field-NYS) and Lettuce C (CEA-Out-of-State), and Lettuce B (Field-NYS) and Lettuce D (Field-Out-of-State). These confirm our preliminary results that consumer are willing to pay higher price for locally grown lettuce compared to the out-of-state grown. We didn't find any statistical difference between the WTP for Lettuce A (CEA- NYS) and Lettuce B (Field-NYS), and Lettuce C (CEA-Out-of-State)

and Lettuce D (Field-Out-of-State) indicating that consumer WTP do not differ between field grown and greenhouse grown lettuce. To further validate these results, we performed a t-test between the local (combining Lettuce A and Lettuce B) and out-of–state (combining Lettuce C and Lettuce D) categories and field grown (Lettuce B and Lettuce D) and greenhouse grown (Lettuce A and Lettuce C) categories. The results again confirm that the WTP for local and out-of-state categories were statistically different but field grown and greenhouse grown were not. We also compared if the WTP for local and out-of-state categories were different when consumers provided additional information and when they were not. We found that there was no statistical difference between the 'with information' and 'no information' sessions for both local and out-of-state categories. Then, we were interested to see if the WTP for the 'with information session' were different between local and out-of-state categories and found that consumer WTP for local lettuce were significantly higher when they received additional information. However, no statistical difference was found between local and out-of-state category when consumer didn't receive any additional information.

4.3 Factors influencing the WTP

The next section presents the estimated results from the Random effects model, using the data collected in our experiments. Table 3 presents the estimated parameters from the random effects GLS model in Equation 1-2 and are similar with the results from (Table 2). The P value for the chi^2 test was <0.01, which indicated that the model fits the data well. We also provide regression results from Ordinary Least Squares (OLS) model for comparison purposes. The results from the OLS model are very close to that from Random effect GLS model except that income and primary shopper are statistically

significant in OLS model. Though the coefficients are same, but they are not statistically significant under the Random effect model. This could be due to the fact that Random effect model is capturing the individual difference. The product characteristics entered in the model were *CEA* (1 = CEA, 0 = Field), *NYS* (1= NYS, 0= Out-of-State), and *INFO* (1 = Information, 0= No Information). The constant then represents the WTP for the Field grown Out-of-State category without providing additional information regarding production systems and origins. The estimated intercept for both OLS and Random Effect model is $1.65 per 8 ounces, which is comparable to the retail price of lettuce in grocery stores. The coefficients for *CEA* and *INFO* are estimated at $0.028/8 ounces and $0.071/8 ounces respectively. These two estimates are not statistically significant suggesting that there is no difference in appreciation of production systems and regarding receiving more information between consumers. The coefficient for *NYS* is estimated at $0.29/8 ounces meaning consumer' are willing to pay 18% more for New York State grown lettuce.

The model is then expanded by including cross-effects of the lettuce characteristics. The intercept for the extended model is higher than the original model. The estimated intercept is $1.75 at 90% significant level meaning that consumers are willing to pay $1.75 for 8 ounces of field grown out-of-state lettuce without receiving more information if everything else held constant. The coefficients for *CEA* and *INFO* are not statistically significant same as the original model. The coefficients for *NYS* is lower for the extended model estimated at $0.16/8 ounces meaning consumers are willing to pay 9% more for New York State grown lettuce compared to the reference group (field-out-of-state-no info). The coefficients for these variables are different likely

due to the fact that the cross effects are now explicitly in the model. Cross effects between origin, production system, and information treatment present consumer WTP when lettuce is grown in CEA and in NYS, when lettuce is from CEA and consumers receive more information, and when lettuce is from NYS and consumers receive more information. The coefficient for (*CEA* X *NYS*) is not found to significantly affect consumer WTP. The coefficients for (*CEA* X *INFO*) and (*NYS* X *INFO*) are estimated significantly at $0.12/8 ounces and $0.29/8 ounces respectively. The results indicate that consumers are willing to pay 11% more when lettuce is from CEA and they receive more information and 18% more when lettuce is from NYS and consumers receive more information compared to the reference group.

The demographic factors that contribute to consumers preferences can also be analyzed with the random effects regression model. All the demographic variables in the extended model are similar to those of the original models. None of the factors were found to significantly affect consumer WTP other than gender. The results indicate that consumers WTP increase by 36% if the consumer is female. The coefficients for other demographic variables are not significant, which indicate that age, education, income, the frequency of buying, whether consumers check the origin and production system, and whether they are primary shopper or not have no impacts on their WTP for the lettuce categories included in our experiment.

In table 5, we present the WTP for different categories of lettuce. This table presents the prices consumers are willing to pay for eight different combinations of lettuce categories with two production systems (CEA and Field), two origins (NYS and Out-of- State), and two information treatments (with information and without

information). Results show that consumers are willing to pay the highest price for CEA-NYS-Info category ($2.13), following Field-NYS-Info ($2.07) and Field-NYS-No info ($1.92) for 8 ounces of lettuce. They are willing to pay the least price for Field- Out-of state- Info category ($1.61). We then performed statistical test to see if the difference between those combinations are statistically significant. The 'Groups' column indicates that two means that have the same letter are not significantly different from each other at a 5% significance level. For example, CEA-NYS-Info category shares different label with Field– NYS- No info, CEA– NYS- No info, CEA– Out-of-State– Info, and Field– Out-of-State– Info categories indicating that the difference between those categories are statistically significant. Among those categories, consumers are willing to pay the highest price for CEA-NYS-Info ($2.13/8 ounces) and then for Field– NYS- No info ($1.92/8 ounces), CEA– NYS- No info ($1.85/8 ounces), CEA– Out-of-State – Info ($1.72), and Field – Out-of-State– Info ($1.61/8 ounces) categories. As there are eight different combinations, some categories share labels with more than one category which indicates that those categories sharing the same label are not significantly different. For example, Field– NYS- No info category is not statistically different than CEA– NYS-No info and Field– Out-of-State – Info category as it shares the same label with the latter two categories.

To summarize, in the original model, consumers are willing to pay $1.65 for per 8 ounces of lettuce for the reference group which is Field-Out-of-State- No info category. They are willing to pay a price premium of $0.30 when the lettuce is from NYS compared to the reference group. Production system and revealing more information don't seem to affect consumers' willingness to pay. Female consumers are willing to pay

around $0.60 more for lettuce. When we include the cross effects of the production systems, origins, and information, we found that consumers are willing to pay $1.75 for per 8 ounces of lettuce for the field grown out of state category when no further information was revealed. They are willing to pay price premium of $0.16/8 ounces for NYS grown lettuce and $0.12/8 ounces for *CEA*INFO* and $0.29/8 ounces for *NYS*INFO* compared to the Field-Out-of-State- No info category. Consumers are willing to pay the highest price for CEA-NYS-Info ($2.13/ 8 ounces) and the least price for Field– Out-of-State – Info ($1.61/ 8 ounces).

CHAPTER 5: DISCUSSION AND CONCLUSION

Determining consumer preferences and willingness to pay (WTP) for CEA grown and locally grown fresh produce is very important for stakeholders as it helps them to decide what type of fresh produce to grow and sell, what to emphasize in their marketing efforts, and what are reasonable prices to charge. However, the literature on local CEA vegetable production and the impact of information on consumer WTP is limited. In this paper, a willingness to pay study has been conducted on loose leaf lettuce to determine potential price advantages for year-round local vegetables grown in Controlled Environment Agriculture (CEA) systems. The specific objective of the study was to measure differences in consumer willingness to pay for loose leaf lettuce with different origins (New York State vs. Out-of-State) and grown under different production systems (CEA vs. field-grown), and to examine whether more detailed information about origin and production system affect consumer willingness to pay.

Considering the average WTP of lettuce (table 2), our results statistically confirm that consumers are willing to pay a higher price for locally grown lettuce compared to the out-of-state grown. At the same time, our results indicate that there is no difference between the WTP for field-grown and greenhouse-grown lettuce. These results are consistent with previous studies which also confirm that consumers were willing to pay higher price for locally grown produce but they were not aware of greenhouse technology and therefore unsure whether or not to pay price premiums for foods grown under such conditions (Yue et al., 2009; Loureiro and Hine, 2002; Narine et al., 2014). Consumer WTP was not different between the information and no information treatment sessions in both local and out-of-state categories. This means that

consumers are indifferent (in terms of WTP) between the two lettuce production systems (CEA-NYS vs. Field NYS) regardless of the origin of production (NYS versus out of state). In addition, our results indicate that consumers' WTP did not change when they received detailed information regarding production systems and origins. This suggests that consumers may not respond to the differences the production systems, even when they receive more information about their characteristics (e.g., employment, year round product availability).

We also compared the WTP between local and out-of-state categories for the 'with information session' and 'no information session'. We found that consumers' WTP for local lettuce was significantly higher than for the out-of-state lettuce when they received additional information. These results indicate that information helps consumers distinguish between local and non-local lettuce, and that this increases the WTP of the local lettuce. In contrast, we found no differences in the WTP for greenhouse-grown and field-grown lettuce between the 'with information' treatment and the 'no information' session. It appears that consumers did not value the differences between CEA-grown and field-grown production systems, even when receiving detailed information about them. Previous studies indicated that consumers do not have enough knowledge regarding CEA or greenhouse production systems and were therefore not concerned if food was produced in a greenhouse or in the field (Padilla et al., 2007; Ilslan et al., 2002). Researchers also indicated that consumers perceived CEA vegetables as 'industrial products' but that they are willing to purchase them provided that greenhouse vegetables are environmentally sound or tastier (Padilla et al., 2007).

Findings from the random effects model (table 3) revealed that NYS-grown and gender were significant factors influencing consumers' WTP for loose leaf lettuce. Results indicate that consumers are willing to pay $0.30 more for 8 ounces of NYS-grown lettuce (an 18% premium over the out-of-state lettuce). This result is consistent with previous studies of fruits and vegetables where consumers were willing to pay significant price premiums for local produce (Martinez, 2010; Loureiro and Hine, 2002; Darby et al., 2008; Brown, 2003). We also find that consumer WTP also increases by 36% among females. Studies done by Yue et al. (2009) and Boccaletti and Nardella (2000) also found similar results that females were more likely to pay more for locally grown vegetables compared with males.

The interactions between lettuce's origin, production system, and information provide interesting insights. Similar to the model without interactions, the coefficient of *NYS* is statistically significant in the model with interaction but the coefficients of *CEA* and *INFO* are not statistically significant. This suggests that consumers are willing to pay 9% more for NYS-grown lettuce compared to the reference group (Field- Out-of-State– No info) when we included the cross effects of the lettuce characteristics. The interaction effect *CEA*Info* was significant and positive, which indicates that consumers are willing to pay 11% more when lettuce is CEA-grown and they receive additional information about product origin and production system compared to the reference group (Field- Out-of-State– No info). The significant and positive coefficient of *NYS*Info* means that consumers are willing to pay 18% more when lettuce is from NYS and they receive more information, compared to the reference group (Field- Out-of-State– No info). Interestingly, we found that although the coefficients of *CEA* and

Info were not significant when treated as separate independent variable, but the cross effects of these two attributes become significant. This indicates that with additional information they are willing to pay higher price for CEA grown lettuce compared to the lettuce grown in Field and in Out-of-State without receiving any additional information category. Local growers can also get a higher premium if the lettuce is from NYS and consumers receive additional information as the coefficient of the interaction term *NYS*Info* is statistically significant.

When we compared the WTP for eight different combinations of lettuce categories, we found that consumers are willing to pay the highest price for CEA-NYS-Info ($2.13/8 ounces) and then for Field– NYS- No info ($1.92/8 ounces) and CEA–NYS- No info ($1.85/8 ounces) categories. These results again confirm that consumers prefer local lettuce and that the production system does not affect their WTP for local produce. They prefer to buy the lettuce grown in NYS regardless of whether it is grown in CEA or in the field and whether they receive information about the characteristics of the production system and the origin or not. These findings have important policy implications. First, our results indicate that consumers are willing to pay the highest price for CEA-NYS-Info category which is a good indication for CEA lettuce producers, stakeholders and industry. Second, as consumers prefer NYS grown lettuce, there is a great opportunity for CEA grown lettuce from NYS so as to be able to provide local lettuce in the off-season. Lettuce producers and channel members can use the estimated price premium identified here as a reference when making their production, pricing, or promotion decisions.

CHAPTER 6: IMPLICATIONS

To assist new and existing NYS producers of Controlled Environment Agriculture (CEA) greenhouse vegetables, this paper investigated the characteristics consumers perceive as important when they make purchase decisions of differentiated fresh produce. It is very important to predict the premium that consumers are willing to pay for the attributes they value. Finding out these price premiums can also help growers to choose the right production methods and profitable value-added attributes to promote. By comparing the premiums with the associated production and marketing costs, the associated parties can make adjustments on their pricing and marketing strategies. Results from our analysis can give growers guidelines on deciding what prices to charge for lettuce with different attributes. Growers, wholesalers, and retailers can compare these price premiums with the actual market price to see whether their charged prices are consistent with consumers' perceived values of these different attributes. To attract more potential consumers, they can design their promotional and marketing strategies. CEA NYS-grown lettuce can be a marketable solution to the problem of seasonal production and limited local food supplies in the state. Future research should be devoted to understand consumers attitudes and perceptions towards new and emerging food production technology and sustainable products. In order to establish new food production concepts, efforts are required to educate consumers, to develop proper positioning of differentiated products and to identify effective communication strategies.

APPENDIX

Figure 1: Example of Information displayed in the First & Second Treatment

First treatment (No information sessions)	Second Treatment (With information sessions)
• Lettuce A: Greenhouse-grown in New York State (NYS) • Lettuce B: Field-grown in New York State (NYS) • Lettuce C: Greenhouse-grown in Out-of-State • Lettuce D: Field-grown in Out-of-State	**Lettuce A: Greenhouse-grown in New York State (NYS)** • Greenhouses allow growers to control growing conditions to produce NYS-grown lettuce available year round • Lettuce produced within NYS travel on average 150 miles to market • Generate NYS jobs year round (1 job per 40 tons harvested)

Table 1. Summary Statistics for Demographic Variables

Variable	Description	Frequency (%)
Gender	0= if male	24
	1= if female	76
Age	Age group,	
	1= 18-24	18
	2= 25-34	24
	3= 35-44	18
	4= 45-54	24
	5= 55-64	14
	6= 65+	2
Education	Highest level of education completed,	
	1= less than high school	0
	2= High school graduate	1
	3= Some college	7
	4= 2 year degree	11
	5= 4 year degree	45
	6= Graduate	26
	7= Professional degree	4
	8 = Doctorate	6
Income	Annual income range,	
	1= less than $20,000	14
	2= $20,000- $29,999	6
	3= $30,000- $39,999	5
	4= $40,000- $49,999	16
	5= $50,000- $59,999	20
	6= $60,000- $69,999	15
	7= $70,000- $79,999	5
	8= $80,000- $89,999	9
	9= $90,000- $99,999	3
	10= more than $99,999	8
Frequency	How often eat lettuce in a week:	
	1= never	0
	2= less than once a week	14
	3= 1-3 times a week	53
	4= 4-5 times a week	24
	5= more than 5 times	9

Origin	How often check origin in a week:	
	1= always	12
	2= most of the time	15
	3= about half the time	13
	4= sometimes	35
	5= never	25
Production system	How often check production system in a week:	
	1= always	5
	2= most of the time	13
	3= about half the time	9
	4= sometimes	27
	5= never	47
Primary shopper	0= if Not	22
	1= if subject is the primary shopper in the household	78

Table 2. Summary Statistics for Willingness to Pay (WTP)

Variable	N	Mean	SD
WTP ($ per 8 ounces)			
Overall	464	1.69	1.16
1) Lettuce A (CEA- NYS)	**116**	**1.84**	**1.19**
No Information	54	1.70	1.32
With Information	62	1.96	1.07
2) Lettuce B (Field-NYS)	**116**	**1.84**	**1.17**
No Information	54	1.78	1.33
With Information	62	1.89	1.03
3) Lettuce C (CEA-Out-of-State)	**116**	**1.57**	**1.13**
No Information	54	1.60	1.35
With Information	62	1.54	0.92
4) Lettuce D (Field-Out-of-State)	**116**	**1.52**	**1.12**
No Information	54	1.60	1.35
With Information	62	1.44	0.89

Table 3. Willingness to Pay Estimates Using Random-effects and OLS Models

Explanatory Variables	OLS Model		Random Effects Model	
	Est. Coeff.	*Std. error*	Est. Coeff.	*Std. error*
Intercept	1.652***	0.0417	1.652**	0.8215
CEA	0.0283	0.1041	0.0283	0.0298
NYS	0.2971**	0.1041	0.2971***	0.0298
INFO	0.0713	0.1129	0.0713	0.2257
Demographic and purchasing habit				
Gender	0.586***	0.1293	0.5886**	0.2585
Age	-0.0300	0.0524	-0.0300	0.1047
Education	0.0081	0.0450	0.0081	0.0901
Income	0.0500**	0.0250	0.0500	0.0501
Frequency	-0.0831	0.0688	-0.0831	0.1376
Origin	-0.0368	0.0640	-0.0368	0.1080
Production System	0.0004	0.0579	0.0004	0.1158
Primary shopper	-0.489***	0.1381	-0.489	0.2761

** p < 0.10; ** p < 0.05; *** p < 0.01.*

Table 4. Willingness to Pay Estimates Using Random-effects Models with interaction term

Explanatory Variables	Random Effects Model (Orig.)		Random Effects Model (Extended)	
	Est. Coeff.	*Std. error*	Est. Coeff.	*Std. error*
Intercept	1.652**	0.8215	1.753*	0.939
CEA	0.0283	0.0298	-0.015	0.042
NYS	0.2971***	0.0298	0.161**	0.058
INFO	0.0713	0.2257	-0.139	0.209
Interaction terms				
CEA X NYS			0.045	0.0289
CEA X INFO			0.125**	0.058
NYS X INFO			0 .296***	(0.000)
Demographic and purchasing habit				
Gender	0.5886**	0.2585	0.5886**	0.2483
Age	-0.0300	0.1047	-0.0300	0.1160
Education	0.0081	0.0901	0.0081	0.1028
Income	0.0500	0.0501	0.0500	0.0617
Frequency	-0.0831	0.1376	-0.0831	0.1280
Origin	-0.0368	0.1080	-0.0368	0.1107
Production System	0.0004	0.1158	0.0004	0.1201
Primary shopper	-0.489	0.2761	-0.489	0.2998

** $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.*

Table 5. WTP for different categories of lettuce

Categories	WTP ($)	Groups
Field – Out of state – No info	1.75	AB DE
Field – NYS - No info	1.92	C
CEA – Out of State - No info	1.74	A DE
CEA – NYS - No info	1.85	B C
Field – Out of state - Info	1.61	AB C
Field – NYS - Info	2.07	E
CEA – Out of State - Info	1.72	D
CEA – NYS - Info	2.13	E

Note: WTP sharing a letter in the group label are not significantly different at the 5% level

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