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The Economics of Animal Health: The Case of Avian Influenza in Vietnam

By

Jennifer Ellen Ifft

A dissertation submitted in partial satisfaction of the

requirements of the degree of

Doctor of Philosophy

in

Agricultural and Resource Economics

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:
Professor David Zilberman, Chair

Professor Gordon Rausser

Professor David Roland-Holst

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Abstract

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Professor David Zilberman, Chair

Highly pathogenic avian influenza (HPAI) is a global health risk, as a major global (human) influenza pandemic could arise from evolution of the H5N1 virus that causes HPAI. This could cause significant loss of human life as well large economic losses. HPAI is considered endemic in many countries, including Vietnam, where HPAI outbreaks began in 2003 and have led to the death or culling of 59.3 million of head of poultry (Burgos et al., 2008) and 59 human deaths (World Health Organization, 2010). Given this risk, there is a need to better understand the economics of the animal health and the poultry sector at all levels. In particular poultry is a sector in transition with both traditional and modern sub-sectors and the response to HPAI may lead to reform of traditional sector. This dissertation considers both the producer response to HPAI outbreaks and evaluates consumer demand for traditional poultry and their willingness to pay for making it safer.

The first chapter provides an introduction to HPAI and poultry sector issues in Viet Nam. The second chapter considers the production response to HPAI outbreaks, specifically the factors driving decision making of small poultry producers after outbreaks. There is currently little empirical evidence on the factors that drive decisions made by smallholders after outbreaks and models predicting farmer behavior are often theoretical or tested using cross sectional data. If the occurrence of epidemics allows farmers to update their beliefs on the likelihood of such epidemics and potentially experience losses, production levels and risk prevention activities should change. I test behavioral predictions based on profit maximizing behavior using survey data with detailed information on poultry production and disease prevention practices

of small scale producers before and after a major avian flu outbreak in 2005, as well as household characteristics. I find that these producers have a small but statistically significant decrease in production due to outbreaks, and that disease prevention practices are also affected.

The third chapter addresses consumer demand for different varieties of chicken, as different chicken production methods lead to differences in quality. In Vietnam, consumer demand for chicken produced under different conditions has important policy implications, including control of HPAI. In this chapter I estimate demand for 3 types of chicken in Hanoi, the capital of Vietnam, and am able to link higher incomes and education to increased consumption of traditionally-produced free range chicken. Although some studies have found evidence of westernization of Asian diets, this study indicates such findings do not extend to all food categories. The findings also indicate that policies that aim to decrease free range chicken production may meet resistance from consumers, even as income increases.

The fourth chapter considers demand for safety labeled free range chicken in Vietnam. The valuation of safe food by consumers in developing countries affected by diseases such as avian influenza, or with food safety issues in general, is very difficult to identify. Products that have safety-branding or credible certification are not common, and food is usually purchased by bargaining at informal markets. Undertaking demand analysis under such conditions is very rare, especially for food characteristics. However, valuation of safety has important implications for livestock disease policies as well as agricultural sector development. I use data that was collected by an FAO project for a pilot certified supply chain for free range chicken in Hanoi and find that consumers in urban Hanoi on average have a welfare gain of about \$0.50-\$1.00 per whole chicken purchase for safety-branding and traceability. This indicates market-based policies have potential to increase the safety of poultry production and trading.

To My Family

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I've not only earned a PhD at UC Berkeley, but met my (future) husband and best friend. I thank John for his love, support and determination to make our relationship last.

Chapter 1

Introduction

In 2003 highly pathogenic avian influenza (HPAI) become a major global public policy issue due multiple outbreaks amongst poultry flocks in southeast Asia and its potential to mutate to an influenza virus that could spread easily between humans. HPAI has been treated like a global public health externality, with significant foreign aid directed to developing countries to combat the spread of HPAI. Vietnam is one of several countries in southeast Asia affected by HPAI risk, as indicated in Figure 1.1.1. This has led to increase attention to many aspects of the economics of poultry production and consumption in Vietnam. My dissertation involves 3 chapters on different aspects of consumer and producer economic behavior that have implications for the control and spread of HPAI. In Chapter 2 I measure the impact of HPAI outbreak severity on smallholder producer behavior. In Chapter 3 I estimate demand for different chicken breeds (or varieties) in Vietnam. Chapter 4 involves estimating the demand for safety labeled free range chicken in Hanoi, the capital of Vietnam.

The food sector in Viet Nam as well as the agricultural sector has been transitioning over several years and will likely continue to transition in the future as incomes increase and production technologies evolve. Avian influenza is a disease that is influenced by a growing poultry population; increased movement of people, animals and goods; and mutation of viruses that thrive in hot or tropical climates. The research in this dissertation recognizes that the behavior of producers and consumers is a integral aspect of this structural transition and its interaction with disease. Producer behavior has not always been well understood empirically, but plays a key role in the prevention or maintenance of disease. Consumers likewise have shopping habits and pref-

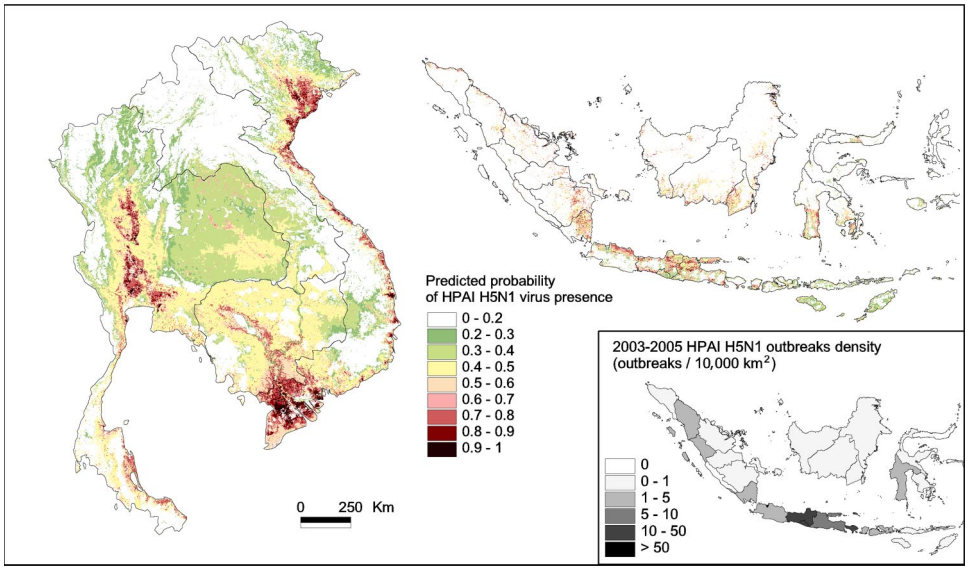
erence that have consequences for the current structure of the poultry sector and the effectiveness of any disease control policies. This dissertation hence considers economic behavior that has important implications for the control of HPAI, as well as other livestock or zoonotic diseases.

The emphasis on different varieties of chicken in this dissertation is deliberate. Small scale production is important to the rural poor in Vietnam, so controlling HPAI risk while maintaining or improving livelihoods is a policy concern. Although chicken production and consumption is often treated in homogeneous manner in surveys, in Vietnam small scale and industrial scale production are highly differentiated, including by production method, supply chain structure and meat quality. The small scale (or free range) sector was initially targeted as the major "culprit" for the spread of the HPAI, although in recent years this view has become more nuanced due to a better understanding of poultry supply chains and disease risk. Small scale production entails risks related to lower biosecurity and increased risk of contact with wild birds, while larger scale production has risks related to poultry being confined to dark, dense and moist housing. Given that the small scale chicken production is ubiquitous on farms across Vietnam, this sector is an important part of HPAI control policies.

The research in this dissertation was motivated by initiatives to reconcile the biosecurity risks related to small scale free range poultry production and the need to have HPAI control policies be consistent with national poverty alleviation objectives. Small scale producers are difficult to regulate, and mandating compliance with biosecurity regulations for the millions of free range poultry producers could be prohibitively costly and ineffective, as well as having a negative impact on livelihoods. Although small scale producers tend to trade locally, and hence might pose a lower biosecurity threat, there is still a need improve biosecurity. Urban retail market premiums for safety certification are a mechanism to reward producers for improving biosecurity while providing a product that consumers prefer, while at the same time contributing to national disease control objectives. Chapter 2 considers how producers behave in absence of incentives to improve biosecurity, while Chapters 3 and 4 consider urban consumer demand for quality and safety, respectively.

1.1 Figures

Figure 1.1.1: Risk of HPAI Outbreaks in Southeast Asia



The relative risk of HPAI outbreaks in Laos, Cambodia, Thailand, and Vietnam, as estimated by and reported in Gilbert et al. (2008)

Chapter 2

Production and Risk Prevention Response of Free Range Chicken Producers in Vietnam to Highly Pathogenic Avian Influenza Outbreaks

2.1 Introduction

Highly pathogenic avian influenza (HPAI) is a global health risk, as a major global (human) influenza pandemic with estimated economic losses of $2 trillion (FAO, et al., 2008) could arise from evolution of the H5N1 virus that causes HPAI. While a global pandemic is a very low probability event, HPAI is now considered to be endemic in many countries and already affects rural communities through its impact on income and nutrition (Peiris, de Jong and Guan, 2007). In Vietnam, HPAI outbreaks began in 2003 and have led to the death or culling of 59.3 million of head of poultry (Burgos et al., 2008), as well as 59 human deaths (World Health Organization, 2010). HPAI is catastrophic for infected flocks, with reported mortality of almost 100%. HPAI, however, can be considered a low probability event for individual farmers—from 2003 to 2008, the total number of birds that died from or were culled due to HPAI were equivalent to about 24% of annual poultry production in Vietnam (Burgos et al., 2008).

In developing strategies to prevent the emergence of an HPAI pandemic as well as other catastrophic events, policymakers need to be able to assess the impact of policies to control HPAI in areas where it is endemic. Such assessments require understanding of how producers change their behavior after outbreaks, which is rarely done in the epidemiological literature. Effectiveness of animal disease control policies can be over-estimated in epidemiological models when economic decision making of producers is not taken into account (Gramig and Horan, 2009). However, little empirical evidence exists on producer response to disease severity, as very few empirical papers have considered responses to livestock disease in a dynamic setting. This chapter is concerned with the behavior of small-scale poultry producers who are ubiquitous in most rural areas and still produce the majority of poultry in Vietnam. Smallholders in Vietnam have diversified farming operations, where poultry is generally a small but important part of the economic activities. The majority of households produce "local chicken," which are native or traditional chicken breeds.

The categories of decisions that affect the risk of HPAI at the farm level are the scale of operation and risk management strategies. We develop a model that innovates through jointly estimating both scale response and behavioral changes, and has the key result that the volume of poultry operations will decrease, but the impact of outbreaks with respect to prevention is indeterminate. These predictions are tested using unique farm-level data from Vietnam, and actual behavior appears to be consistent with these predictions.

2.2 Background and Literature

This paper is concerned with small scale poultry producers, who are prevalent in most rural areas, diversified in production activities, and still produce the majority of poultry in Vietnam. Poultry is generally a small but important part of the economic activities or rural households, and the majority of household still produce "local chicken", which might be interpreted as native or traditional chicken breeds. Although much is unknown about the degree to which certain risk factors contributed to the spread of HPAI, presence of surface water, mixing of wild birds and domestic birds, import of infected birds, and elevated levels of movement of people and poultry (Burgos et al., 2008) appear to be key risk factors.

Several practices can lower the risk individual farmers face for contracting avian influenza. The level of these practices, henceforth referred to as risk prevention practices or RPPs, has a large externality. RPPs can be put into three categories: (1) activities that decrease contacts with humans, livestock, and other birds, such as enclosing poultry; (2) vaccination for HPAI[1], and (3) improvement of hygiene, such as manure composting or hand washing. Given the short life cycle of poultry, producers also have an option to decrease risk through shifting away from poultry production and towards other economic activities. Our challenge is to develop and apply a conceptual framework that would assess the role of risk management strategies versus size management in response to variable levels of HPAI risk.

A common finding in animal health economics is that private actions to control disease and prevent risk are lower than the level that is socially optimal (for example, Wolf 2005 and Bicknell, Wilen and Howitt 1999). The private risk prevention response to HPAI is generally considered to be less than socially optimal, so most policies are focused on strengthening or completing private action. Using numerical simulation methods, Gramig and Horan (2009) find that disease-ecology models that do not take into account economic behavior tend to overstate policy effectiveness. Parameters for economic response that are based on actual behavior would improve the design of HPAI control policies, especially if used jointly with epidemiological modeling.

These parameters can also help explain how some policies might cause risky behavior by producers. Hennessy (2007) finds multiple equilibria for investment in risk prevention in areas affected by endemic livestock disease, several which are not socially optimal. The author further conjectures that regions with fragmented production systems have weak incentives to investing in decreasing disease risk, given complimentary of prevention technologies and production scale and role of the disease environment in discouraging increases in production scale.

Given the prevalence of behavior that is not socially optimal, HPAI control policies are focused on strengthening or complementing private action. Ranjan and Lubowski (2005) develop a model of private and public disease control options and find that inefficient mixes of control options can lead to

[1]Vaccination through mass campaigns was widespread towards the end of the survey period, but would not have provided immunity for individual flocks unless undertaken at very specific times in the production period. Results should be interpreted in this context.

perverse incentives for producers. They suggest that "realistic estimates of key parameters," such as how operations respond differently to disease risk, could improve estimation of optimal policy response.

While economists have developed a massive literature on the response to financial risks, there is a smaller literature on health risks. Lichtenberg and Zilberman (1986) introduced a model of health risk management where risk is the probability of a bad event, death, or a disease for an individual. They introduce a risk-generating function that may be dependent on choices as well as socioeconomic variables and policy conditions. While most of the literature (see Lichtenberg 2010) applies the risk-generating function to analyze actions that aim to reduce risk to individuals, in this paper risk is the probability that a flock of chicken will be killed by HPAI.

Our analysis considers producer choices to reduce the damage from disease risk. Several conceptual studies on producer behavior aim to control stochastic mishap in analyzing alternative liability rules, such as Zivin, Just and Zilberman (2005), which models choices of producers that control the probability of a mishap. In our article, the mishap is HPAI risk, and the actions that decrease HPAI risk would involve a change in behavior and/or technology. However, our empirical analysis considers changes in behavior in different time periods, and thus the assessment of probability of risk may follow a learning process that has been explicitly incorporated in adoption models (Feder, Just and Zilberman 1985). Furthermore, in our analysis we consider not only choices that affect the likelihood of disease but also the choice of scale of operation. As the adoption literature suggests, scale of operation is closely related to risks facing producers (Just and Zilberman, 1983).

Thus, our analysis follows previous empirical studies on multiple production choices in animal agriculture as well as theoretical studies. Jointness of technology adoption decisions is an important consideration in many of these studies. Feder, Just and Zilberman (1985) suggested that adoption studies need to expand beyond consideration of dichotomous adoption choices and allow for complementarities between related adoption decisions. Zepeda (1994) jointly estimated productivity and technology adoption by California dairy farmers, with results that indicated that joint estimation improves efficiency.

Theoretical studies related to HPAI specifically and livestock disease in general also confirm the need to jointly account for production scale and adoption of RPPs. Beach, Poulos and Pattanayak (2007) describe a household production function with risk of avian influenza as a function of both

of disease prevention effort and a poultry production function. Hennessy (2006) finds that disease risk can create decreasing returns to scale, which could explain a decrease in production levels when disease risk increases.

This chapter also relates to how farmers react to information on the likelihood of future risk, as past outbreaks of HPAI are a good predictor of the ambient risk environment. Lybbert et al. (2007) find that herders in Ethiopia respond to weather forecasts in the case of lower-than-normal rainfall. The authors suggest that access to drought mitigation strategies could be influencing this behavior, and that information provision alone might not be sufficient to change behavior. Similarly, the new environment or "health production conditions" should play a large role in explaining optimal production responses after HPAI outbreaks. Sherlund, Barrett and Adesina (2002) find that taking into account environmental production conditions is critical for inference related to smallholder technical efficiency.

Animal health economics originally focused on cost benefit analysis of disease control options; modeling or simulation based approaches to determine optimal control decisions; and quantification of the cost of animal disease (Dijkhuizen, Huirne and Jalvingh, 1995). In addition to considering the change in environment and information, producers might have responses that vary over time. Very few papers have considered private animal health decisions in a dynamic setting. Some papers have considered factors that influence adoption of specific technologies such as vaccination, but tend to focus more on the role of demographic factors, farm characteristics, and extension initiatives as opposed to production decisions (for example, Bhattacharyya et al. 1997 and Heffernan, Thomson and Nielsen 2010). Gramig, Wolf and Lupi (2010) have advanced this literature through using cross-sectional data to determine the importance of disease risk reduction of livestock disease RPPs in adoption decisions.

2.3 Model

We assume that all farmers are diversified and raise traditional (local) chicken, which not a time-intensive activity. Thus, we do not use a household model, which is especially effective in addressing time allocation issues. Instead we assume that farmers are interested in profits from poultry. Some of the utility from chicken is derived from not needing to buy meat at the market and the rest from selling poultry at the market, for which the price in both cases

is constant and equal to P. The flock of chicken is facing a risk of catching a devastating disease like HPAI, where infection kills the entire flock. The farmer can control the probability of infection by controlling flock size N, and prevention efforts, denoted by X. The probability of avoiding the diseases is $h(N, X, R)$ where R is a risk indicator. The function $1 - h(N, X, R)$ is the damage function, similar to that commonly used in the literature on pest control (Lichtenberg and Zilberman, 1986). We assume complementarity between risk and population or flock size and that the marginal effectiveness of prevention declines with the risk factor, which along with standard assumptions implies that $h_N \leq 0$, $h_{NN} \leq 0$, $h_X \geq 0$, $h_{XX} \geq 0$, $h_R \leq 0$, $h_{RR} \leq 0$, $h_{RN} \leq 0$, and $h_{RX} \leq 0$. With these assumptions, the distribution of the farmer profits is

$$\begin{array}{rll} PN - C(N, X) & \text{with probability} & h(N, X, R) \\ -C(N, X) & \text{with probability} & (1 - h(N, X, R)). \end{array}$$

For simplicity, we assume expected profit maximization, as we would not gain much by introducing risk aversion to the analysis. The reason is that poultry is relatively a small fraction of the overall operation of the household and presents a low level of exposure to risk so that risk aversion considerations do not change the outcomes much (Just and Zilberman, 1983). Thus, the optimization problem of the farmer is:

$$\underset{X,N}{\text{Max}} PN\left[h(N, X, R)\right] - C(N, X). \tag{2.3.1}$$

The first-order conditions are

$$Ph(N, X, R) + PNh_N - C_N = 0 \tag{2.3.2}$$

and

$$PNh_X - C_X = 0. \tag{2.3.3}$$

Condition (2.3.2) suggests that the optimal flock size is determined where the expected value of marginal product of flock size, $\text{EVMP}(N, X, R)$, is equal to the marginal cost of the bird. EVMP is equal to the expected revenue per bird, $Ph(N, X, R)$ plus the expected marginal loss of size PNh_N, which is negative. Condition (2.3.3) states that the optimal prevention effort is

determined so that the expected marginal gain from prevention of PNh_X is equal to the marginal cost of prevention C_X. To derive some comparative statics, we totally differentiate equations (2.3.2) and (2.3.3), where:

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix} = \begin{bmatrix} PNh_{XX} - C_{XX} & -[Ph_X + PNh_{NX} - C_{NX}] \\ -[Ph_X + PNh_{NX} - C_{NX}] & 2Ph_N + PNh_{NN} - C_{NN} \end{bmatrix}.$$

We let $D = ad - bc = (2Ph_N + PNh_{NN} - C_{NN})(PNh_{XX} - C_{XX})$ - $(Ph_X + PNh_{NX} - C_{NX})^2 > 0$. Comparative static analysis leads to,

$$\begin{bmatrix} {}^{dN}/_{dR} \\ {}^{dX}/_{dR} \end{bmatrix} = -\frac{1}{D} \begin{bmatrix} a(Ph_R + PNh_{NR} + bPNh_{XR} \\ c(Ph_R + PNh_{NR} + dPNh_{XR} \end{bmatrix}. \tag{2.3.4}$$

Equation (2.3.4) suggests that the impacts of an increase in riskiness on flock size and prevention efforts can be decomposed to two effects each. The marginal effect of riskiness on flock size (${}^{dN}/_{dR}$) is the sum of (1) the direct effect of risk on size $-a(Ph_R + PNH_{NR})/D$, which is negative since $a < 0$, $D > 0$, and both Ph_R and $PNh_{NR} < 0$ and (2) the effect of risk on size through its impact on prevention $-bPNh_{XR}/D$. Note that $h_{XR} > 0$ while b has two negative elements, $-Ph_X$ and $-PNh_{NX}$, and a positive one, C_{NX}, which to some extent may cancel one another. When the negative effects dominate, the two effects have contradictory signs. Otherwise, increase in risk reduces flock size. If the direct effect dominates (for example, when is h_{XR} very small), then even when the effects have different signs ${}^{dN}/_{dR} < 0$.

The impacts of increased riskiness on preventive efforts can be decomposed to (1) direct effect, $-dPNh_{XR}/D$ which is positive (since d is negative), and then (2) impact education in population $-c(Ph_R + PNh_{NR})/D$. Note that $c = b$ and assuming that both h_R and $h_{NR} < 0$, the impact on riskiness on prevention through increase in population is negative in the plausible case where $c < 0$. If h_{XR} is very small and the marginal effect of prevention increases with risk, much of the direct effect may be slight. If h_{NR} is substantial, the population effect may dominate and an increase in riskiness will lead to reduction of prevention. Thus, our conceptual analysis leads to two empirical hypotheses. The first is that the increase in disease risk will reduce farm size. The second is that increase in risk may either increase or decrease prevention efforts, and finding the exact direction is an empirical challenge.

Data

The data used in this study were collected in the fall of 2006 as a part of a national study to assess the economic and social impacts of HPAI in Vietnam (Agrifood Consulting International, 2007). Households were randomly selected from eight rural communes in four districts throughout Vietnam, for a total of over 1,300 observations. Communes usually consist of a small cluster of villages; the population in the survey communes varied from 1,340 to 5,652 households. The survey focused on small-to-medium scale poultry production and collected information on RPPs, prices, and poultry production from October 2004-September 2005 and October 2005-September 2006. The first period corresponded to the second wave of HPAI outbreaks, and the second to the third wave. The first wave of HPAI outbreaks began in late 2003; information was also collected on HPAI infection in poultry from 2003. Data on demographic characteristics, economic activities, etc., for each household were also collected. Figure 2.6.1 shows how the data is structured in relation to HPAI outbreaks. The spatial distribution of HPAI outbreaks that roughly corresponds to Figure 2.6.1 can be found in Figure 2.6.2.

The households in the survey were poor relative to other Vietnam households, as income per capita was approximately $350 per year (Agrifood Consulting International, 2007), compared to the gross domestic product of $711 (current $US) per capita in 2006 (World Bank, 2010). Only 20% of household heads had completed high school or higher levels of education, and non-farm income accounted for only 5-35% of total income across communes. 1168 households, or 86 percent of the sample, reported producing chicken at the time of the survey, and the majority of households in the survey produced less than 50 head of poultry per year. There was also significant turnover in the number of chicken between the two periods in the survey, as indicated in Table 2.6.1.

Table 2.6.2 has key summary statistics for variables used in analysis of production and risk prevention responses. Only a small percentage of farms experienced HPAI outbreaks, although there was considerable variation in incidence across communes. The low number of households impacted was likely due to the small size of farms and quick containment of outbreaks by the authorities. Farms on average produced about 28 chickens each year, with over half of farms having them enclosed in a fenced area or other poultry housing. The net effort in RPPs is indicated by the "Risk Prevention Index" (RPI), which is based on an index that weights each individual activity based

on effectiveness and the effort involved. This index increased by about 18% during the project period. This index allows for aggregate measurement of effort while taking into account that farmers might select different ways to prevent risk. Some of the practices in the index include hand washing, foot washing, changing shoes, and changing clothes after working with poultry. Also included are separating poultry from other animals, security of the poultry enclosure, manure management practices, provision of adequate feed, and restricting access to poultry. Details on which particular activities were included in the RPI and their relative weighting can be found in Table 2.6.3. Most activities saw statistically significant changes between the two period.

2.4 Analysis

We test the predictions of our model using two types of reduced form analysis of production and risk prevention levels during the second and third waves. We first consider the impact of commune (j) level outbreaks at time t, (R_{jt}), over the two previous years on the number of chicken produced by farm i, N_{ijt}, and N_{ijt} weighted by investment in housing ($i(H_{ijt})$). R_{jt} refers to the percent of farmers in a particular commune with flocks contracting HPAI. We don't add a measure for intensity because contraction of HPAI generally results in death of an entire flock, and R_{jt} is representative of all farmers in a commune with the same scale of production as farmers in our sample. Housing is indexed by function $i(\cdot)$, which estimates the level of protection for a flock where $i(\cdot) \in (0, 1]$. Several different types of index functions, $i(\cdot)$, were tested, with results that were similar to those presented in this chapter. Housing (H_{ijt}) is used in $i(\cdot)$ as opposed to the RPI due to its preventive effect being more transparent. The decision of whether or not to keep chicken enclosed is a key biosecurity decision with a strong impact on the likelihood of avoiding HPAI infection (Burgos et al., 2008).

This model is estimated using individual farmer fixed effects (FE), with the number of outbreaks reported by bordering communes as an instrument for local outbreak levels, R_{jt}. This instrumental variable is used to address concerns of time variant heterogeneity among individual producers that might impact local outbreak levels, and the instrumented R_{jt} is represented by $R^{\star}_{jt}$.

The second approach is to jointly estimate the impact of commune level HPAI outbreaks on N_{ijt} and the RPI (X_{ijt}), using a three-stage least squares

model and the same instrumental variable for commune level outbreaks as in the FE model. Three-stage least squares estimation places strong distributional assumptions on the standard errors as well as assuming homoskedasticity (Cameron and Trivedi, 2009), so we will interpret the results in the context of the findings of the FE model. Our specifications for the FE model are

$$N_{ijt} = \alpha + \gamma_1 R^{\star}_{jt-1} + \gamma_2 R^{\star}_{jt-2} + \beta_1 P_{ijt} + \beta_2 d_{ijt} + \beta_3 I_t + \varepsilon_{ijt} \tag{2.4.1}$$

and

$$N_{ijt}\left(H_{ijt}\right) = \alpha + \gamma_1 R^{\star}_{jt-1} + \gamma_2 R^{\star}_{jt-2} + \beta_1 P_{ijt} + \beta_2 d_{ijt} + \beta_3 I_t + \varepsilon_{ijt}. \tag{2.4.2}$$

The variable d_{ijt} refers to whether or not a household was raising duck, as they take up space and affect risk. I_t is an indicator variable for the second period. Feed, chick, and broiler prices are denoted by P_{ijt}. The two equations estimated jointly using three-stage least squares are

$$N_{ijt} = \alpha+\gamma_1 R^{\star}_{jt-1}+\gamma_2 R^{\star}_{jt-2}+\beta_1 x_{ij}+\beta_2 P_{ijt}+\beta_3 d_{it}+\beta_4 D_i+\beta_5 I_t+\varepsilon_{ijt} \tag{2.4.3}$$

and

$$X_{ijt} = \alpha+\gamma_1 R^{\star}_{jt-1}+\gamma_2 R^{\star}_{jt-2}+\beta_1 x_{ij}+\beta_2 P'_{ijt}+\beta_3 d_{it}+\beta_4 D_i+\beta_5 I_t+\varepsilon_{ijt}. \tag{2.4.4}$$

District FEs are denoted as D_i and demographic characteristics, which include education, wealth, and other factors, are x_{ij}. Identification is achieved by excluding X_{ijt} from equation (2.4.3), as we believe that in practice producers might determine production levels before investing in risk prevention. Feed and chick prices are excluded from equation (2.4.4) for identification purposes. Furthermore, we believe that these variables would not have a meaningful impact on risk prevention choices relative to other factors.

The F-statistics from the first stage of instrumental variables estimation are reported in Table 2.6.4 and indicate a strong, statistically significant relationship between the endogenous variables and the instruments. Prices are excluded from some estimates of the FE model, as they are exogenous to the individual farmer but might be considered to be endogenous to the

market. Households that experienced HPAI outbreaks are also excluded, as their choice set is expected to be quite different from the rest of the population, although this exclusion does not affect the results substantially.

Our results, found in Table 2.6.4, indicate that production levels do decrease in responses to higher levels of outbreaks, although the strongest response seems be in response to recent outbreaks. The estimates for γ_1 and γ_2 indicate the change in broiler numbers for a 1-percentage point increase in commune level outbreaks. Using the FE model in the first column of Table 2.6.4 indicates that a move from a 1% to 2% outbreak level will lead to a decrease in flock size by 2.96 head. Given the average flock size found in Table 2.6.2, this is approximately a 10% average decrease in production levels. The impact from outbreaks two years ago is weaker and not as statistically significant. Excluding prices decreases the magnitude of the impact of outbreaks, but the results are consistent. The impact of outbreaks on weighted output is of lower magnitude than for non-weighted output, indicating that risk prevention levels affect the response to outbreaks.

Results from the three-stage least squares model are consistent with the FE model, in that production levels decrease as higher levels of outbreaks are experienced. Risk prevention appears to decrease as a result of higher levels of outbreaks in the past year (R_{jt-1}) and, although γ_2 is weakly statistically significant and just above the 10% significance level, it is also positive and of a higher magnitude. This might be the result of decreased production levels as well as a slower learning response for new behaviors relative to production changes.

2.5 Conclusion

Our results suggest that smallholders in areas where HPAI is endemic have integrated the risk of HPAI into their production activities. Thus, their response to increased risk is quite moderate. Namely, in response to outbreaks in their locality, they may reduce slightly their scale of operations, and the risk prevention effort appears to decline. This decline may correspond to the decreasing production levels, or risk prevention responses might simply be delayed, as adopting new behaviors might entail more learning and change of habits than decreasing numbers of chicken. Furthermore, the adjustment to risk is dynamic, and it may take time for risk prevention activities to be adopted in response to increase in perceived risk.

The results also show that disease prevention efforts are not separable from production choices, and thus they have to be investigated simultaneously. We find counterintuitively that areas that are more adversely impacted by HPAI might experience lower levels of adoption of risk prevention practices immediately afterwards, and this result holds when we control for education, wealth, and other demographic factors. Thus, policymakers should not expect increased risk prevention in response to outbreaks. This study demonstrates that even data on choices during a short period of time allows better assessment of the adjustment of smallholders to animal disease risk, and suggests that longer term data would contribute to a deeper understanding of this process. Our results show that the adjustment of smallholders to HPAI risk is rather modest, likely due to the small share of poultry in their diversified farming operations. It is especially important to investigate the extent that these results hold for larger producers, where poultry is a major source of household income, and to better understand the dynamic adjustment of these poultry producers to HPAI risk. This extra knowledge is likely to contribute to improved prediction of supply response and risk generation as well as better policy design.

2.6 Figures and Tables

Figure 2.6.1: Data Structure

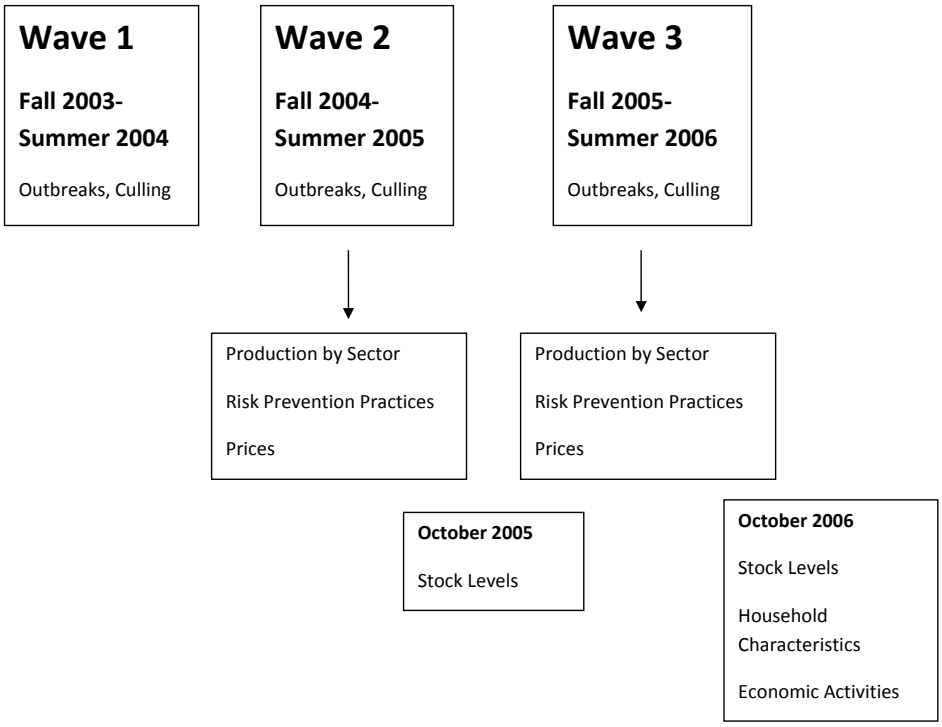
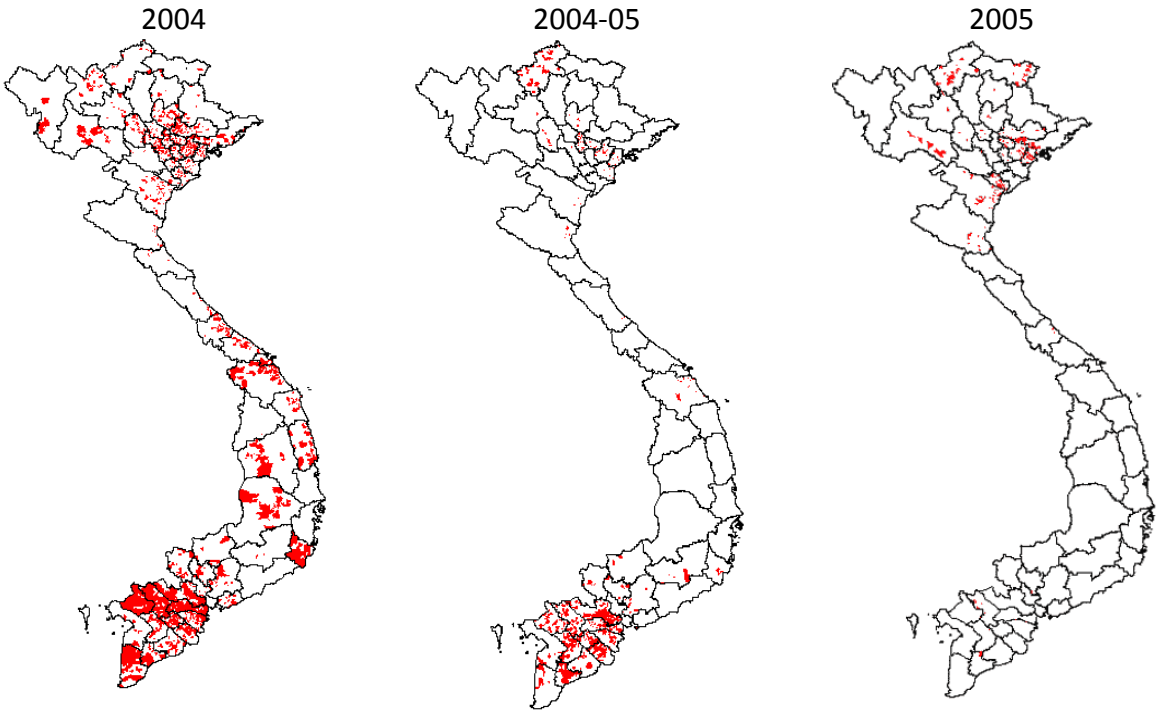


Figure 2.6.2: Spatial Distribution of HPAI Outbreaks in Vietnam



Source: Pfeiffer et al. (2007)

Table 2.6.1: Changes in Production Levels

2006	No Chicken	Small	Medium
2005 - No Chicken	64	149	15
2005 - Small	42	809	23
2005 - Medium	9	45	111
2005 - Large	0	3	6

Small = < 50 chicken produced annually; medium = 50-200 chicken produced annually; large = >200 chicken produced annually

Table 2.6.2: Summary Statistics

	Wave 1 Oct. '03-Sept. '04	Wave 2 Oct. '04-Sept. '05	Wave 3 Oct. '05-Sept. '06
Farms with HPAI outbreaks, %	0.67 (0.99)	1.27 (1.76)	0.50 (1.07)
Number of chickens produced	-	28.1 (39.97)	27.8 (29.76)
Enclosed chicken housing, % of farms	-	55.3 (49.7)	54.4 (49.8)
Risk Prevention Index	-	4.3 (2.7)	5.09 (2.59)

Standard deviation is denoted in parentheses

Table 2.6.3: Risk Prevention Activities

Activity	**Wave 2**	**Wave 3**	**Pr(W2=W3)**	**Description**	Weight
Housing	2.78	2.81	0.001	1 = Confined, 5 = Rice Fields	3
Manure Mgt	2.36	2.38	0.002	1= Not cleaned up, 3 = Composted	2
Mixing	7.5%	8.0%	0.206	Allow poultry to mix with other animals	2
Vaccination⋆	34.2%	78.9%	0.000	Vaccinate Poultry (for any disease)	–
Enough Food	90.6%	90.5%	0.655	Provide enough food for poultry	1
Restrict Access	19.8%	25.3%	0.000	Restrict access to poultry area	2
Disinfect⋆	51.3%	70.0%	0.000	Disinfect poultry area	–
Hand wash	3.00	2.63	0.000	1=always, 5 = never	1
Foot wash	3.13	2.79	0.000	1=always, 5 = never	1
Change clothes	3.88	3.71	0.000	1=always, 5 = never	1
Change shoes	4.03	3.89	0.000	1=always, 5 = never	1
Index	4.36	5.09	0.000	Exclude policy-related	–

⋆Vaccination and disinfection were driven by district policies instead of individual behavior, so they are excluded from the RPI

Table 2.6.4: Regression Results

	FE Total Output	FE Total Output	FE Weighted Output	FE Weighted Output	3SLS Output	3SLS Prevention
Outbreaks	-2.96*	-5.59*	-1.95*	-3.64**	-3.97**	-34.93**
$t-1$	(1.55)	(3.06)	(1.04)	(1.83)	(2,23)	(16.74)
Outbreaks	-1.56	-1.75	-0.54	-1.19	-5.12	62.59
$t-2$	(1.35)	(1.61)	(1.24)	(0.88)	(4.83)	(38.70)
F-Stat 1S $t-1$	310.9	349.2	310.9	349.2	163.1	132.2
F-Stat 1S $t-2$	221.1	488.39	221.1	488.39	314.6	331.3
N	1904	1904	1605	1605	1751	1751
Prices?		yes		yes	yes	yes

* and ** for 10% and 5% significance levels, respectively; standards errors for the FE models are robust to correlation at the commune level.

Chapter 3

Demand for Chicken Varieties in Northern Vietnam

3.1 Introduction

Policy makers in Vietnam have considered elimination of the informal poultry sector as part of the strategy to control avian flu. However in Vietnam people do not treat all chicken equally and seem to favor traditional chicken from the informal sector. Chicken has an important cultural role in Vietnam, with most families eating chicken during the New Year and certain lunar holidays. Awareness of how different breeds of chicken are raised is high amongst urban households, with consumers (correctly) linking breed and production environment to desired meat quality characteristics. Supermarkets have grown in Hanoi, but are still not popular places to purchases fresh produce and meat. The vast majority of households prefer to consume fresh food that is purchased daily in small markets near their home (Maruyama and Trung, 2007). Very few studies, if any, to estimate chicken demand have been undertaken in Vietnam, although avian influenza outbreaks have led to increased interest in the development of the poultry sector in Vietnam. Of existing studies related to chicken consumption, data has not been used for formal demand analysis Figuié (2007); Phan and Reardon (2007).

In Vietnam consumer preferences for chicken have serious implications for poultry sector development, rural poverty and HPAI risk because different types of chicken are linked to different production systems. Chicken is gen-

erally sold as one of 3 types: local, crossbred and industrial. Local [1] chicken refers to native breeds of chicken that are raised in a free range environment, by "traditional methods" with minimal feed. Local chicken are more likely to be raised on small farms by poor households, and production of this type of chicken is important to the livelihood of rural households. Industrial chicken are fast-growing exotic breeds raised in a confined environment with concentrate feed. Crossbred chicken are hybrids varieties of native and exotic breeds, and are generally raised in a garden or 'confined grazing area'. Crossbred chicken is sometimes fed small quantities of concentrate feed. Each type of production poses unique disease risks: local and crossbred chicken could have more contact with wild birds, while industrial chicken is raised in dense, dark and damp conditions that are more conducive to the spread of HPAI.

Consumer preferences for chicken produced in different systems have important implications for HPAI control. If the price or quality of a certain type of chicken changes due to a policy, consumers response could undermine the impact of that policy through changing purchase behavior or quantity consumed. For example, a policy that increases the price of local chicken could lead to consumers becoming more likely to purchase chicken from less biosecure informal sources. Although there are multiple interesting aspects of consumer behavior, basic knowledge of price and income elasticities for different varieties of chicken in Vietnam is very limited. This issue is not limited to Vietnam; existing data on consumption of differentiated products is sparse in developing countries. In this paper we utilize data from a unique but relatively short survey to estimate poultry demand. We estimate an incomplete demand system using the Linquad model, which is consistent with economic theory. Demographic characteristics are included in the model, which are useful in predicting how demographic change could impact chicken demand.

In addition to providing information on consumer demand for policy, this analysis also contributes to understanding of food consumption trends in developing countries. That wealthy consumers in developing countries have shifting food consumption patterns has become a stylized fact. Barkema, Drabenstott and Welch (1991) note that in the US consumers want nutrition, convenience and variety. Food systems have become more consumer driven,

[1] What is often known outside of Vietnam as 'free range' chicken, will henceforth be referred to by the more direct translation of 'local chicken'. Crossbred chicken that is sold in Vietnam would often fit the definition of chicken that in the US or Europe is labeled as'free range'.

partially in response to food that has more convenience and other valued-added characteristics(Kinsey and Senauer, 1996). As incomes increase in the US, the demand for food that is more convenient increases (Blaylock et al., 1999). Although this type of food has advantages of convenience of preparation and hygiene, quality in terms of freshness and other characteristics is often sacrificed. Movements towards 'local food' and organic food in Europe and the United States are seem, amongst other trends, as a reaction to the decline in food quality (Gilg and Battershill, 1998). Consumers in developing countries appear to moving in a direction of purchasing more convenient food in supermarkets (Reardon et al., 2003). Because industrial chicken is a more "modern food" and local chicken is generally sold through traditional markets in a less processed form, demand analysis of chicken consumption can can shed light on how the demand for traditional vs. modern chicken is changing in Vietnam as it going through a process of economic growth. Viet Nam has seen growth in real gross domestic product above seven percent from 1995-2005, and the poverty rate decreased from 58% in 1993 to 16% in 2006 (World Bank, 2011*a*).

3.2 Background and Literature

3.2.1 Chicken Consumption in Hanoi

Very limited data exists on consumption of differentiated chicken products in Hanoi. We utilize a household survey conducted by an FAO project in 2007 in Hanoi, the capital of Vietnam,. This survey aimed to identify current shopping habits and preferences of Hanoi residents, related to food consumption and specifically chicken and other livestock products. Data was collected on average weekly spending on livestock products, how much chicken is purchased per week on average, where it is purchased, and what concerns consumers about the quality and safety of chicken meat. The survey also included basic demographic information, weekly food spending for food consumed inside and outside of the home, detailed information on characteristics of chicken purchases, experience with chicken branding, and willingness to pay for a safety guarantee. The member of the household that was responsible for purchasing food that is consumed within the household was interviewed.

Hanoi has 9 inner (or urban) districts and all interviews took place in these

districts. This survey utilized a two-stage sampling design, based on districts and randomly selected blocks in each district. All household dwelling units in each block were combined at the district level for systematic sampling. The total number of targeted observations was 1000, from which observations allocated at the district level proportionally to population size. 1215 surveys were collected. A total of 26 households reported never consuming chicken and many variables were left unanswered for these households. This is only about 2% of the total sample, so we removed them from our analysis. Hence any of our results might be considered to be applicable to 'Hanoi households that consume chicken' and represent about 98% of the population.

Summary statistics for these variables and other important variables that are used in our analysis can be found in Tables 1-3. 96 percent of all households report shopping once daily, confirming that it is customary that those in charge of household food preparation in Hanoi visit their local wet market daily. This is despite the fact that most households in Hanoi are middle income and own refrigerators. For many households, it appears that chicken is not consumed more than once weekly, with average household consumption of chicken being less than the weight of a small dressed chicken. 80 percent of chicken is purchased at wet markets and 5% is purchased at supermarkets, with the rest being purchased from informal sources. 55% of all households purchased only local chicken, 14% purchased only industrial chicken, and 5% purchased only crossbred, with the remaining households purchasing more than one type of chicken. All three types of chicken are widely available in the wet markets located in every neighborhood. 71% of households reported regularly purchasing government-certified chicken, although only 18% reported at least occasionally purchasing branded chicken.

Households were asked to rank various concerns on a scale of 1 to 5, related to taste, pricing, safety generally, and specific risk factors. Many households were concerned about the taste of this kind of chicken, as well as convenience of purchase. Other survey results indicate that many consumers are concerned about the government's ability to regulate and inspect for chicken safety. Certified chicken indicates that the chicken meets government inspection requirements, usually a stamp on the chicken but also potentially a safety certificate.

Prices reported by households were consist with estimates from surveys by Vietnamese government organization (Institute of Policy and Strategy for Agricultural and Rural Development, 2007)and also prices reported from a survey of 200 wet market vendors that was conducted around same time (Ifft

et al., 2008*c*). The price of local chicken is about double that of industrial chicken, with crossbred chicken about 'in between'. Local chicken, at 60,000 VND/kg (about $4, at the time of the survey $US1 = 16,000 Vietnamese dong (VND)), is very expensive, while industrial chicken costs on average 32,000 VND/kg. We further see a large amount of statistically-significant price dispersion between different districts for the same type of chicken, indicating that if this is not due to quality differences there is not full competition between wet markets, whose vendors often source from small slaughterhouses. The author has also observed that prices for the same type of chicken in Hanoi widely vary between wet markets.

3.2.2 Food Demand Trends

Pingali (2007) finds that Asian diets are being "Westernized" with economic growth and urbanization, leading to more diverse diets and increased protein consumption, and posits that this growing demand cannot be met by the traditionally food supply chain. In Hanoi, the capital of Vietnam with a large middle-income population, survey data indicates that the majority of consumers purchase only traditionally-produced (local) chicken, despite widespread availability of cheaper and "easier to prepare" options. These consumers also are more likely to purchase chicken at wet markets or from more informal retailers, with supermarkets having a 5% market share for chicken. Further, the price of local chicken is double that of industrial chicken, which alone supports a strong preference for local chicken and Pingali's (2007) assertion that the traditional food supply chain might have trouble meeting growing demand. This could be related to customs and cultural factors that increase preferences for this type of chicken. Heiman et al. (2001); Heiman, McWilliams and Zilberman (2004) find that demand for specific types of meat can be affected by religion and cooking habits and other lifestyle differences, in addition to income and price. In Hanoi, it appears that such cultural factors that are prevalent at the aggregate level are still driving chicken preferences, as opposed to other trends that lead to increased purchases of modern foods. Phan and Reardon (2007) discuss how performance of fresh fruit and vegetables is lower than other food categories in supermarkets in developing countries. In Vietnam, poultry meat (as well as other types of meat) seems to follow this pattern, given that supermarkets have an overall low market share for chicken.

Blaylock et al. (1999) discuss how time-related preferences and moderate

food prices are driving food consumption choices over health and nutrition information in the United States. How consumers value their time in relation to food purchase and preparation is a key factor in demand patterns. Shepherd and Tam (2008) find that consumers in urban areas of Vietnam often do not accept fresh vegetables with less pesticide use if appearance is affected. In this case, preferences for appearance are stronger than preferences for pesticide use. Likewise, consumers preferences for traditionally-produced poultry in Hanoi appear to be driven by experiential traits such as flavor and texture of meat, instead of preferences related to point-of-sale hygiene or official quality certification. The majority of industrial chicken consumers in our study report buying cuts instead of the whole bird, implying that industrial chicken is more likely to be processed. These consumers are also more likely to use supermarkets, which indicate that industrial chicken is more likely to be certified through official channels. The structure of poultry supply chains in northern Vietnam also support that industrial chicken is more likely to be sold through formal channels where government or private company certification of quality is available (Ifft et al., 2008*a*). A large amount of local chicken is purchased live, although the dangers of live bird trade have been well publicized by the government. Industrial chicken is often sold through more controlled supply chains, but consumers continue to prefer local chicken. Although this might reflect consumer distrust in these institutions, it also provides evidence that production method plays the key role in consumer decisions for chicken consumption.

Ali, Nguyen and Ngo (2006) predict income growth in Vietnam will lead to increased demand for livestock products, fruits and aquatic products in the future in Vietnam, as well as higher willingness to pay for quality. From household survey data, they show how many products have price differences that are attributable to quality, and that prices paid by higher income households are significantly higher. Mergenthaler, Qaim and Weinberger (2007) are further able to show that demand for fruits and vegetables in Hanoi from modern supply chains are highly income elastic, although supermarkets currently only have a 5.6% market share. These studies would indicate that chicken sold through supermarkets (often frozen) and chicken that is more processed would have a positive income elasticity. Given the previously discussed price differences between chicken types, it is relevant to discuss how perceptions of quality factor into demand analysis.

Most food demand studies for developing countries utilize household surveys (such as LSMS surveys) and use broad categories of food types, such

as beef, poultry and pork (for example Mdafri and Brorsen (1993); Jabarin (2005)). Studies that focus on demand for quality attributes, credence goods, safety, etc. are more likely to be undertaken in developed countries. There is strong evidence that this is a large market – Masters and Sanogo (2002) find that the economic surplus from certification of nutrient density in infant foods in Malawi is over $1 million annually. Senauer (2006) notes that "many developing and transition countries have a large and growing market for high value food products." He supports this with evidence for household data in Peru's capital and suggests that the growth the middle class in China and India will have a large impact on global food markets. The middle class in Vietnam is growing, and changes to urban food demand will have serious implications for Vietnam's agricultural sector.

Several studies for willingness to pay for meat quality attributes have been undertaken in developed countries, with strong findings supporting for willingness to pay for quality. These studies often find that consumers are willing to accept much higher prices for goods with desired quality attributes. Alfnes et al. (2006) find that consumers in Norway have a high willingness to pay for (darker) red color in salmon through experimental methods. Kiesel, Buschena and Smith (2005) find that voluntary labeling increase the demand for 'recombinant bovine growth hormone free milk' through using retail scanner data. Dhar and Foltz (2005) find that organic and and rBST free labels have significant benefits for consumers through estimation of a complete demand system for different types of milk.

What is seem by consumers as 'quality' can vary widely across countries. Lusk, Roosen and Fox (2003) find that consumers in 3 European countries are more concerned about beef that has been fed genetically modified beef than consumers in the United States. Wang et al. (1998) report that backyard-produced livestock cuts that have excess fat often have a price that is 30% lower in urban markets in China. This pricing contradicts our finding of higher prices for traditionally produced chicken in Vietnam. Wang et al. further discuss how cuts of meat that are lower value in the US, such as variety meats, often have the same price as cuts considered to be high quality in the US. Despite "westernization" of Asian diets and global food sector trends such as supermarkets, it is important to note that quality preferences remain heterogeneous across countries and regions and may not always be related to foods that can be defined as modern or "western".

Eales and Unnevehr (1988) find that consumers choose specific meat products rather than aggregates such as beef or chicken. They suggest that de-

mand for convenience may be driving increased chicken consumption, instead of a structural change in preferences for these 2 meat aggregates. Senauer, Sahn and Alderman (1986) show that the opportunity cost of time for women can shift consumption choices to ready-to-eat bread over cereals. In Vietnam, market vendors reported to the author that convenience as perceived by consumers is not related to the level of processing but the ability to quickly purchase fresh products near the home. This is also confirmed by the findings of Cadilhon et al. (2006). Fuglie (1994) finds that demand for potato has been increasing in Tunisia, which is a non-traditional food product. Potatoes were positively associated with increases in income, a contradiction to previous studies that found starch consumption to decline. The year round supply of potatoes in Tunisia is suggested to be a contributing factor the growth in demand. Convenience of supply might also be considered an important quality characteristic that helps explain continued demand for local chicken that is largely sold in local wet markets. This does not imply that chicken consumption choices are limited by supply – industrial chicken is also available in wet markets and average household consumption of chicken less than one whole chicken. Even if visits to supermarkets are infrequent, consumption of chicken is also infrequent.

3.3 Empirical Model

Our analysis uses household level cross sectional data from Vietnam, from the only known data set with consumption data for different varieties of chicken. In addition to data on attitudes and demographics, we also have detailed data on how each of the 3 specific breeds of chicken are purchased by households. Individual (or household) data is advantageous, as it shows how individual households react to price and income changes, instead of whole markets. Households can adjust breed and quality based on prices, not only quantity. The data is measured by average weekly chicken consumption and average prices for chicken, which captures consumption from all sources and allows for comparison of equivalent units between households. Cross sectional data is sometimes seen as less desirable for demand analysis, especially in locations with widespread availability of retail scanner data and panel studies (Capps, 1989). Cross sectional data also might not have enough variance across regions or locations to allow for measurement of response to price. However, cross sectional data does have some advantages. Times series data

can also be affected by structural shifts in demand that are correlated with increasing income, hence biasing income elasticities (Huang and Bouis, 2001).

3.3.1 Censored Demand System

Several households in our data set consume only 1 type of chicken; some consume 2 types and very few consume all 3 types. Hence before undertaking economic analysis, censoring must be addressed. The Heckman selection procedure and an alternative developed by Heien and Wessels have been used in many older demand studies to address censoring; however new methods have been developed that have been shown to be more efficient. The method developed by Shonkwiler and Yen (1999) is an improvement on previous methods to address censoring, through improving interaction between the censoring rule and the mean of the latent variable (consumption). Tauchmann (2005) found that Heckman estimators might perform better than Shonkwiler and Yen's (SY) method (199) under OLS or seemingly unrelated regression (SUR), but we will use a different type of estimation than this that is actually preferred for SY. Tauchmann also notes that the SY estimator has been used several times in various demand studies. Fabiosa and Jensen (2003) model an incomplete demand system using a selection procedure developed by SY, and we borrow from their notation below. This is based on a model with latent variables and a selection mechanism as follows.

$$x_i^* = x(p_i, y_i, demo_i) + \varepsilon_i, \qquad d_i^* = z_i'\lambda_i + \mu_i$$

$$d_i = 1 \text{ if } d_i^* > 0, \quad d_i = 0 \text{ if } d_i^* \leq 0; \quad x_i = d_i x_i^*$$

Here x_i is quantity consumed of a particular type of chicken, p is a vector of prices, y is income (measured by total food expenditure), and *demo* is demographic characteristics. We observe x_i only if the household reported consumption of a particular type of chicken. Here z_i is a vector of characteristics that affects the probability whether or not a particular household consumes a certain type of chicken, and γ_i is a coefficient vector. In our estimation, we will use survey data not utilized in our structural demand equation as a part of z_i to meet the exclusion restriction. After estimation of d_i^*, demand estimation should be adjusted as followed based on the methodology developed by SY.

$$x = \Phi q(p, y, demo) + \kappa_i \phi + \mu_i$$

$\Phi$and ϕ are respectively the cumulative density function and standard normal density of our estimated d_i^*. The coefficient κ_i will be determined endogenously by estimation of the demand system. We estimate the selection mechanism using probit estimation for the following equation.

$$Pr(Buy_{ij}) = f(p_i, y_i, demo, pref, district, week)$$

The variable $pref$ refers to the variables found after the demographic variables in Tables 1-3 and discussed previously. We also include indicator variables for district the week the survey was taken. We add several variables related household preferences for poultry that are not typically included in demand estimation, but do could have an impact of the type of chicken that is purchased. For example, households who put more weight on the taste of chicken might be likely to purchase local chicken.

3.3.2 Incomplete Demand System Estimation

Demand estimation with Linquad has both theoretical and practical advantages for this particular data set. Linquad was developed through a series of several studies, including LaFrance et al. (2002); LaFrance and Hanemann (1989), and is well suited towards incomplete demand systems. It imposes less theoretical restrictions for estimation than models such as AIDS, or the classic 'Almost Ideal Demand System' developed by Deaton and Muellbauer (1980). Many demand studies have to make an assumption of weak separability in order to estimate a complete demand system (Dhar and Foltz (2005); Eales and Unnevehr (1988); Nayga and Capps (1994)), which we can avoid with estimation of an incomplete demand system. Linquad is derived from a quasi-expenditure function that satisfies integrability, hence allowing for direct welfare analysis and inference based on well-behaved consumer preferences. Linquad further allows for demand estimation for a subset of goods, which is ideal for our data set which has mostly data on chicken, without prices or consumption of other goods. Linquad estimation is based on a quasi-expenditure function, where marshallian demand is derived using Shephard's lemma. We will not show all the detailed properties and derivations of Linquad here because this has been done in detail in several other papers such Fang and Beghin (2002).

Most of the usual constraints required for demand analysis are not necessary with Linquad, especially the "adding-up constraints" of AIDS. Linquad satisfies 4 of the main requirements for demand models, with most requirements met by construction. The main constraint that must be imposed is that $\beta_{ij} = \beta_{ji}$, which satisfies the requirement that the matrix of compensated substitution effects must be symmetric. The second requirement is that consumption is non-negative, which achieved by using actual quantities consumed in our model. Linquad also has demands that by construction are homogeneous of degree zero, so no constraints related to this are necessary. Finally, by using a measure of income in analysis instead of expenditure on the food in the demand system, Linquad by construction meets the requirement of $p'x_i(\cdot) < y$.

The derived model for Linquad, adjusted by Fabiosa and Jensen (2003) for demographic characteristics, is as follows:

$$x_i = \alpha_i + \beta_i p + A_i demo_i + \gamma_i \left(y - p'\alpha - p'Ademo - 0.5p'Bp\right).$$

Our estimating equation for Linquad demand estimation is as follows, again using the notation of Fabiosa and Jensen (2003).

$$x_i = \Phi\left[\alpha_i + \beta_i \hat{p} + A_i demo + \gamma_i \left(e\hat{x}p_i - \hat{p}'\alpha - \hat{p}'Ademo - 0.5\hat{p}'B\hat{p}\right)\right] + \kappa_i\phi + \mu_i$$

This system can be jointly estimated using nonlinear least squares, using an iterated feasible generalized nonlinear least squares estimator that converges to the maximum likelihood estimates (Green, 2003). For Linquad, the main constraint that we need to impose is that $\beta_{ij} = \beta_{ji}$, or that the substitution effects are equal across equations.

As indicated in Tables 3.6.8 and 3.6.9, standard errors have been estimated using a cluster bootstrap. Bootstrapping standard errors is appropriate in many situations, especially when estimators are particularly complex. In any type of multiple-stage estimation, standard errors from the final estimating equation must be adjusted. Because we have more than one stage of estimation, standard errors must be adjusted. By using a cluster bootstrap that completes each iteration by estimating all stages, we are able to non-parametrically estimate standard errors for otherwise complex estimators with some unknown properties. All of our standard errors are robust to

correlation at the block level and take into account all steps taken to estimate our variables of interest.

Income elasticities are reported in Table 3.6.10 and (unadjusted) income and education elasticities are reported in Table 3.6.11. Own and cross-price elasticities are reported in Table 3.6.12 (the justification for including unadjusted elasticities will be discussed in the next section). For all estimations, we compute elasticity based on average values of our variables of interest. We first calculated the elasticities using standard formulas for Linquad, which require adjustment for censoring mechanism. Below are the formulas for prices and income (technically total food expenditure, *exp*) elasticities, respectively (Fabiosa and Jensen, 2003). The price and income (adjusted for the censoring mechanism) elasticities are calculated as follows:

$$\epsilon_{ij}^{a} = \Phi_i \epsilon_{ij} + \frac{\phi_i \lambda_{ij} p_j}{x_i} \left(x_i - \kappa_i(z'\lambda)\right)$$

$$\epsilon_{i}^{a} = \Phi_i \epsilon_{i} + \frac{\phi_i \lambda_{iy} y}{x_i} \left(x_i - \kappa_i(z'\lambda)\right)$$

3.3.3 Robustness Checks

The data used in our survey is at the individual level, hence we avoid many of the aggregation problems with using market level data. However, if there are quality differences between chicken purchased our demand estimates might be biased. In addition to estimating our demand system with reported prices, we will estimate our demand model while controlling for potential unobserved quality differences reflected in price. Cox and Wohlgenant (1986) have developed a methodology for adjusting prices for quality effects in demand analysis. Their methodology is based on an assumption that quality and quantity decisions of households are weakly separable, and that quality effects can be explained by differences in the "composite commodity" (breed of chicken in our case). This assumption is appropriate to chicken consumption in Vietnam. Chicken is a relatively homogeneous product with minimal processing, and is usually only purchased as whole or half (cuts/parts) chicken. Chicken can also be purchased live, and from different sources such as supermarkets or corner sellers (small shops).

Following Cox and Wohlgenant, the first step to is to derive mean block prices, as block are our smallest sampling unit. Because 80% of chicken is bought at wet markets and most neighbors have their own small wet market,

the block is an appropriate level for which to derive mean prices, or BMP. This is also an important step because of price dispersion in local markets. We also used demographic characteristics (d_i), food expenditure (exp_i), and shopping habits/chicken characteristics (s_{ij}). We use the subscript j chicken breed, as some chicken characteristics that are only applicable to certain types of chicken. For example, no one reporting buying crossbred chicken in the countryside and or live industrial chicken. We also use an indicator variable for the week (w) that the survey took place to account for any quality differences in current market conditions that might have impact reporting of average prices. From the mean prices we calculate the difference between BMP and own price (D or $BMP\ Dev$) and save the residuals ($\hat{e}_{ij}$) from the following regression:

$$D_{ij} = \delta_0 + \delta_1 d_i + \delta_2 exp_i + \delta_3 s_{ij} + \delta_4 w_i + e_{ij}$$

We are then able to calculate quality adjusted prices for each household as $BMP_j + \hat{e}_{ij}$. Households not reporting price in our sample are considered to face average block prices for a specific type of chicken. Our main assumptions here are that we have been able to fully identify "quality", as well as that quality and quantity decisions are separable. Cox and Wohlgenant argue that although simultaneity can be a problem when search costs are high, search costs are small for any food product that makes up a small portion of the overall budget. Further, in Vietnam consumers usually shop at the same location and are very familiar with the products that each market vendor has on offer. To show the effect of price variation that is not associated with quality differences, we report regression results with and without these adjusted prices. In the models with quality adjusted prices, we use the quality adjusted prices to estimate both the censoring and the demand estimation.

In this study our main measure for income is total weekly food expenditure, which includes expenditure on food purchased both for consumption in and out of the home. Complete demand system estimation makes an assumption of weak separability of expenditure, which generally does not hold. Dhar, Chavas and Gould hence recommend that endogeneity of expenditure is a general issue that must be addressed in food demand analysis. Although we use an incomplete demand systems approach, we cannot rule out the possibility that households who have strong preferences for chicken increase total food expenditure relative to total income. Although chicken is a small part of the overall food consumption, meat is a very high portion of total

food expenditure. We hence consider how to test for the robustness of the impact of expenditure on chicken consumption.

Ideally, we would use an instrumental variable to correct for potential endogeneity of expenditure. Because we use a small household survey instead of an LSMS survey, additional data on a factors related to income is limited. Education is the one variable that is (highly) correlated with food expenditure (see Table 3.6.4) but is arguably not unrelated to demand. To use education as an instrument variable for expenditure, we would have argue that education impacts chicken consumption only through its impact on income, hence meeting both the requirements for an instrument. We however are concerned it would be difficult to disprove that education leads to greater knowledge about food safety risks or lifestyle changes that are unrelated to income.

Although education might not be a suitable instrument for total food expenditure, it is strongly correlated with income and hence food expenditure, and therefore a similar effect of education (used as a proxy for expenditure) on chicken consumption as expenditure would support our estimation results. It is very likely that education has a much stronger impact on demand through its relationship with income, as opposed to any influence on attitudes or knowledge. In Vietnam, military service is mandatory for men unless a university education can be attained, which wealthier families can afford through private institutions. We might also expect that more educated, wealthier households would prefer more processed foods or food from supermarkets. For example, educated individuals might also be more concerned about the hygiene conditions in wet markets, which might lead to contradictory results for education and expenditure for traditional varieties (local and crossbred). On the other hand, positive education elasticities for local or crossbred chicken would strongly support the result of positive income elasticity for traditionally produced chicken.

We will estimate Linquad under 3 specifications: (1) with expenditure and education as a demographic variable (2) with expenditure only and (3) with education as proxy for expenditure. Specifications (2) and (3) are considered robustness checks for the impact of expenditure and education. We will only consider elasticities from specification 1, except to compare education elasticities from specification 3 to income (food expenditure) elasticities from specification 1. We do not adjust education elasticities, because in specification 3 we are proxying education for income and some of the parameters for adjustment are associated with income. Instead we provide unadjusted

income and education elasticities for a more direction comparison.

3.4 Discussion of Results

The results of estimation of quality-adjusted prices can be found in Table 3.6.5. For local chicken, whether or not it was purchased from the countryside or live has a negative impact on prices. Live chicken, although often considered desirable by Hanoi residents, has less processing and is sold informally, which might lead to lower prices. The week that the survey was taken also appears to have an impact on local chicken prices, likely due to the impact of recent price shocks on participants' estimation of average prices. Our model overall seems to have low predictive power for price deviations for crossbred and industrial chicken, although several demographic factors have an impact on industrial chicken price. Having more children or adults in the household is correlated with lower prices for industrial chicken, while food expenditure is positive and food expenditure squared is negative.

Results of the estimation of the selection mechanism can be found in Table 3.6.6 and Table 3.6.7. When using quality adjusted prices, having more child or adults makes households less likely to purchase local chicken, although we see no statistically significant effect with market prices. Higher food expenditure is associated with buying more local chicken and less crossbred industrial chicken. Concern for price and taste have the anticipated signs, as local chicken is considered tastier and industrial chicken is cheaper. Coefficients on quality-adjusted prices also have the expected signs, and indicate a high level of substitutability between different breeds of chicken. Coefficients on market prices are generally consistent, especially for own-price coefficients. Experience purchasing branded chicken and belief that chicken safety can be improved is positively correlated with crossbred chicken purchase. Households who have higher rankings for concern about market hygiene are less likely to be crossbred and industrial chicken and more likely to buy local chicken chicken. Concerns about the origin of chicken are associated with less purchases of crossbred chicken. The "Risk Index" variable gives greater weight to households who had high rankings for all safety-related concerns, and is associated with a small increase in purchase of crossbred and industrial chicken.

Results from our structural demand estimation can be found in Tables 3.6.8 and 3.6.9 and relevant elasticities can be found in Tables 3.6.10, 3.6.11

and 3.6.12. As predicted, education and expenditure both have a positive correlation with local chicken demand across all specifications. In specifications 5 and 6, education proxies for expenditure and our results indicate that any potential endogeneity of expenditure does not diminish our result that increased expenditure is correlated with greater consumption of local chicken. Under some specifications, crossbred chicken is associated with higher food expenditure, while education has a negative association with crossbred chicken consumption. Under almost all specifications, industrial chicken has negative but not statistically significant relationship with food expenditure and income. Overall, we find evidence that local chicken is associated with higher incomes, but no such evidence for industrial chicken and contradictory results for crossbred chicken.

When market prices are used, we see the expected (negative) signs on own-price elasticity for local and crossbred chicken (Table 3.6.12), but not for industrial chicken. Although our own-prices effects for all types of chicken are not robust to use of quality-adjusted prices, substitution effects appear to be strong, especially for local and industrial chicken. The changes in estimates of own-price elasticity after use of quality-adjusted prices indicates that quality bias can create endogeneity in cross-sectional demand analysis. Given the strong substitution effects apparent in results from both Table 3.6.6 and 3.6.8, it appears that households change quality and type of chicken over (or in addition to) quantity. This is not surprising given that the majority of chicken tends to be purchased in discrete units: either whole or half chicken. This type of substitution indicates that in general cross sectional demand analysis undertaken at the individual level might not show the type of price effect that is often apparent at the market level.

Family structure also appears to impact the level of chicken consumption. Households with more children consume more local chicken, but single adult households do not. Demographics do appear to have a statistically significant relationship with crossbred chicken consumption. Households with more children and grandparents (other adults) are more likely to consume industrial chicken.

3.5 Conclusion

One purpose of this analysis has been to improve understanding of chicken demand in urban Vietnam, so that avian influenza control policies might be

better informed. The government currently has policies to manage avian flu that focus on industrialization of the chicken sector. This strategy might not only adversely impact the rural poor, it might also be ineffective if urban consumers continue to prefer free range poultry (local chicken). My results show that higher income households are more likely to consume more local chicken. Furthermore, the impact of income or expenditure (as well as education) on industrial chicken consumption is negative for all specifications. This result is consist with local chicken being preferred to industrial chicken, and industrial chicken being an inferior good.

Structural changes to the food industry will have an on future consumption. If preferences do not drastically change with further income growth, the results provide evidence that households will demand more local chicken in the future. Regulatory policies might affect market access in various ways, but consumer demand will likely continue to drive production of local chicken. It is likely that if preferences for local chicken stays strong the price premium will remain, and the private sector will continue to 'supply'. These results support that to effectively manage avian flu, the government should include local chicken producers (small rural households) in its plans to control the spread of HPAI.

The results of our analysis provide evidence that households are sensitive to changes in the price of chicken. This provides a potential explanation for the continued sale of live chicken and uncertified slaughtered chicken in Hanoi. Given a limited capacity to enforce biosecurity requirements in urban markets, policies that increase the price of local chicken or chicken in general could lead to an increase in the level of unregulated or illegal poultry trade. Government policies for poultry sector restructuring should carefully consider how price changes could to a decrease in biosecurity. For example, restricting backyard chicken production in certain areas could increase prices and give incentives to traders from other areas to bypass regulated trading channels (such as registered slaughterhouses and wholesale markets with a safety certification system).

Finally, our results show that in Vietnam traditionally produced chicken is still dominant despite the growth of income and availability of cheaper alternatives. Although developing countries might generally be experiencing increasing demand for processed and more convenient food, it is also likely that demand for traditional food in some areas will remain strong. The analytical approach developed in this paper could be extended to other sector and countries, especially in developing Asian countries where fresh meat, veg-

etables and fruits are still bought in wet markets in cities where supermarkets are prevalent. Future studies on meat demand should consider disaggregating by production method, and the type of incomplete demand system analysis used in this paper provides a useful framework. Future studies would ideally utilize time series data, with more precise measures of income and instrumental variables for price. Related studies will also have to continue to address issues of censoring in demand system estimation.

3.6 Tables & Figures

Table 3.6.1: Summary Statistics: Consumption

Variable	**Mean**	**(Std. Dev.)**	**Min.**	**Max.**	**N**
Consumption Local Chicken (kg/week)	0.6	(0.6)	0	4	1188
Consumption Crossbred Chicken (kg/week)	0.1	(0.2)	0	3	1189
Consumption Industrial Chicken (kg/week)	0.2	(0.4)	0	5.9	1189
Average Price of Local Chicken	3.9	(0.7)	1.1	7.5	946
Average Price of Crossbred Chicken	2.7	(0.3)	1.9	3.8	141
Average Price of Industrial Chicken	2.1	(0.3)	1.6	3.8	399
Averave Weekly Food Expenditure (USD)	31.2	(14.1)	5.6	177.5	1192
Education Level	3.5	(0.7)	1	5	1192
Single Adult HH	0	(0.1)	0	1	1192
Number Children	1.2	(0.9)	0	5	1191
Other Adults	1.3	(1.2)	0	8	1191
Total Household Members	4.5	(1.5)	1	17	1191

HH stands for household

Table 3.6.3: Summary Statistics: Chicken Characteristics

Variable	Percent	(Std. Dev.)
Percent HHs Purchasing Local Chicken, any type	80	(40)
Percent HHs Purchasing Crossbred Chicken, any type	12	(32)
Percent HHs Purchasing Industrial Chicken, any type	33	(47)
Percent HHs Purchasing All 3 Types of Chicken	0	(4)
Percent HHs Purchasing Local Chicken Live	29	(46)
Percent HHs Purchasing Local Chicken Whole	38	(48)
Percent HHs Purchasing Local Chicken in Parts	22	(41)
Percent HHs Purchasing Crossbred Chicken Live	0	(5)
Percent HHs Purchasing Crossbred Chicken Whole	2	(14)
Percent HHs Purchasing Crossbred Chicken in Parts	11	(31)
Percent HHs Purchasing Industrial Chicken Live	0	(0)
Percent HHs Purchasing Industrial Chicken Whole	1	(12)
Percent HHs Purchasing Industrial Chicken in Parts	33	(47)
N	1192	

HH stands for household.

Table 3.6.2: Summary Statistics: Attitudes and Shopping Habits

Variable	Mean	Std. Dev.	Min	Max
Concern for Taste (1-5)	4.7	(0.5)	1	
Concern for Price (1-5)	2.1	(1.1)	1	5
Concern for Market Hygiene (1-5)	2.1	(1.2)	1	5
Concern for Chicken Origin (1-5)	3.6	(1.1)	1	5
Concern for Chicken Disease (1-5)	4.5	(0.8)	1	1
Concern for Quality of Chicken Inspection (1-5)	3.7	(1)	1	5
Percent of HHs Believing Chicken Safety Should be Improved	73.7	(44)	0	100
Percent HHs that Currently Purchase Branded Chicken	17.9	(38.3)	0	100
Percent HHs that Regularly Purchase (Govt) Inspected Chicken	72.1	(44.8)	0	100
Percent of Chicken Purchased in a Wet Market (Cho)	81.5	(36.1)	0	100
Percent of Chicken Purchased in Supermarkets	5.4	(18)	0	100
Percent of Chicken Purchased Through Home Delivery	0.5	(6.7)	0	100
Percent of Chicken Purchased in the Countryside	3.8	(18.3)	0	100
Percent of Chicken Purchased from a Corner Seller	6.5	(24.4)	0	100
Percent of Chicken Purchased from a Wholesale Trader	2	(13.3)	0	100
N		1192		

HH stands for household.

Table 3.6.5: Quality Adjusted Price Estimation

	BMP Dev Local	BMP Dev Cross	BMP Dev Indust.
	(1)	(2)	(3)
Supermarket	.001	.0009	.003**
	(.001)	(.0009)	(.001)
Countryside	-.003***	-.0003	.00009
	(.0009)	(.002)	(.001)
Corner Seller	.001*	.002	-.0002
	(.0007)	(.001)	(.0004)
Informal Trader	.0001	-.0009	-.002
	(.001)	(.002)	(.001)
Live Local Chicken	-.801***		
	(.039)		
Govt Inspected Chicken	-.034	-.013	-.005
	(.039)	(.054)	(.026)
Local Chicken Parts	-.079*		
	(.042)		
Branded Chicken		.009	.025
		(.061)	(.037)
Industrial Chicken Whole			.142**
			(.056)
Live Crossbred Chicken		.033	
		(.185)	
Cross Chicken Parts		-.217***	
		(.076)	
Middle School	-.152	.091	.014
	(.098)	(.150)	(.040)
High School	.029	.077	-.030
	(.037)	(.051)	(.025)
University Postgrad	-.012	-.108	-.015
	(.084)	(.125)	(.090)
Weekly Total Food Exp	.005	.010	.007**
	(.003)	(.010)	(.003)
Number Children	.002	-.051	-.046*
	(.029)	(.077)	(.025)
Other Adults	-.043	-.042	-.049*
	(.027)	(.077)	(.025)
Food Exp Squared	7.50e-06	-.0001	-.00007*
	(.00002)	(.0001)	(.00004)
Family Size Squared	.0005	.006	.003
	(.002)	(.007)	(.002)
Obs.	945	141	399
Adjusted R^2	.388	.027	.042

*, **, and *** for 10%, 5%, and 1% significance levels, respectively

Table 3.6.4: Food Expenditure by Education Level

Education Level	Total Expenditure	Per Capita Expenditure*	Number
Primary	10.9	4.9	2
Middle School	18.6	7.0	75
High School	27.4	8.2	452
Univ. Undergraduate	35.0	9.6	620
Univ. Postgraduate	40.4	11.2	42
Total	31.2	9.0	1191

*Per capita expenditure is calculated with a weight of 0.4 for children and 0.8 for "other adults". Other adults include all adult family members minus 2 (unless there is only one adult in the family) and are most likely grandparents.

Table 3.6.6: Probit Estimation of Selection Mechanism with QA Prices

	Buy Local	Buy CB	Buy Ind
	(1)	(2)	(3)
Single Adult HH	-.012	-.599	.265
	(.372)	(.587)	(.371)
Other Adults in HH	.056	.012	-.013
	(.049)	(.058)	(.041)
Number Children	-.031	.105	.073
	(.056)	(.067)	(.049)
Concern Price	-.358***	.117**	.258***
	(.045)	(.056)	(.041)
Concern Taste	.417***	-.035	-.261***
	(.086)	(.119)	(.080)
Qual Adj Price Local	.055	.007	-.098
	(.107)	(.118)	(.091)
Qual Adj Price Ind	-.240	-.186	-.320
	(.240)	(.351)	(.211)
CB Available	-.115	.833	-.950*
	(.609)	(.777)	(.574)
CB Price Interacted	.019	.262	.228
	(.218)	(.242)	(.203)
Weekly Total Food Exp	.024***	-.009	-.012***
	(.005)	(.006)	(.004)
Branded Chicken	-.298**	.852***	-.017
	(.127)	(.130)	(.111)
Can Improve	-.233	1.564***	.007
	(.515)	(.531)	(.441)
Concern Mkt Hygiene	.209*	-.369**	-.334***
	(.119)	(.168)	(.113)
Concern Origin	.096	-.284***	.006
	(.082)	(.103)	(.071)
Concern Disease	-.085	-.160	.078
	(.094)	(.098)	(.080)
Concern Inspection	.126	.054	-.068
	(.084)	(.095)	(.071)
Risk Index	-.003*	.003*	.003**
	(.001)	(.002)	(.001)
Obs.	1190	1190	1190
Psuedo R^2	.191	.223	.111

*, **, and *** for 10%, 5%, and 1% significance levels, respectively

Table 3.6.7: Probit Estimation of Selection Mechanism with Market Prices

	Buy Local	Buy CB	Buy Ind
	(1)	(2)	(3)
Single Adult HH	-.312	-.755	.325
	(.405)	(.682)	(.377)
Other Adults in HH	.020	.074	-.004
	(.052)	(.064)	(.041)
Number Children	-.029	.140*	.077
	(.060)	(.076)	(.049)
Concern Price	-.391***	.084	.287***
	(.048)	(.063)	(.041)
Concern Taste	.356***	.206	-.245***
	(.090)	(.146)	(.080)
Local Price	-.877***	.209**	.214***
	(.094)	(.096)	(.065)
Industrial Price	-.667***	.724**	-.154
	(.245)	(.349)	(.205)
CB Available	-1.571**	10.629***	-3.110***
	(.620)	(.941)	(.563)
CB Price Interacted	.531***	-2.995***	.892***
	(.198)	(.275)	(.177)
Weekly Total Food Exp	.031***	-.012*	-.014***
	(.006)	(.007)	(.004)
Branded Chicken	-.079	.695***	.013
	(.141)	(.156)	(.116)
Can Improve	-.182	1.791***	.030
	(.551)	(.604)	(.449)
Concern Mkt Hygiene	.255**	-.550***	-.356***
	(.128)	(.196)	(.114)
Concern Origin	.035	-.288**	.013
	(.088)	(.115)	(.073)
Concern Disease	-.066	-.103	.054
	(.102)	(.114)	(.082)
Concern Inspection	.128	.007	-.055
	(.089)	(.107)	(.072)
Risk Index	-.002	.004**	.003**
	(.001)	(.002)	(.001)
Obs.	1190	1190	1190
Psuedo R^2	.291	.408	.132

*, **, and *** for 10%, 5%, and 1% significance levels, respectively

Table 3.6.8: Linquad Estimation Results, Part 1

	Educ & Exp		Exp Only		Educ Proxy Exp	
	Reported (1)	Qual Adj. (2)	Reported (3)	Qual Adj. (4)	Reported (5)	Qual Adj. (6)
Local Own Price	-0.18	-0.05	-0.16	-0.03	0.04	0.02
	(0.06)***	(0.05)	(0.06)***	(0.05)	(0.11)	(0.19)
Cross Own Price	-0.64	0.18	-0.63	0.18	-0.47	0.16
	(0.23)***	(0.30)	(0.22)***	(0.30)	(0.22)**	(0.29)
Indust Own Price	0.21	0.19	0.16	0.18	0.14	0.19
	(0.22)	(0.20)	(0.21)	(0.20)	(0.21)	(0.20)
Local Cross Subs	0.12	0.07	0.12	0.07	0.09	0.16
	(0.07)*	(0.06)	(0.07)*	(0.07)	(0.14)	(0.10)
Local Indust Subs	0.20	0.11	0.21	0.11	0.17	0.12
	(0.09)**	(0.07)	(0.10)**	(0.08)	(0.10)*	(0.09)
Cross Indust Subs	0.04	0.05	0.01	0.04	-0.02	-0.001
	(0.11)	(0.11)	(0.10)	(0.11)	(0.12)	(0.12)
Local Exp	0.01	0.01	0.01	0.01	-	-
	(0.004)***	(0.005)**	(0.004)***	(0.006)**	-	-
Cross Exp	0.01	0.01	0.01	0.01	-	-
	(0.01)	(0.008)*	(0.008)	(0.008)	-	-
Indust Exp	-0.01	-0.003	-0.007	-0.004	-	-
	(0.003)*	(0.004)	(0.003)*	(0.004)	-	-
Local Educ	0.13	0.12	-	-	0.15	0.12
	(0.04)***	(0.04)***	-	-	(0.04)***	(0.06)**
Cross Educ	-0.12	-0.06	-	-	-0.06	-0.01
	(0.10)	(0.07)	-	-	(0.11)	(0.08)
Indust Educ	-0.05	-0.03	-	-	-0.05	-0.004
	(0.06)	(0.05)	-	-	(0.05)	(0.06)

*, **, and *** for 10%, 5%, and 1% significance levels, respectively; Standard errors are reported in parenthesis and are robust to correlation at the block level

Table 3.6.9: Linquad Estimation Results, Part 2

	Educ & Exp (Specification 1)		Exp Only (Specification 2)		Educ Proxy Exp (Specification 3)	
	Reported	Qual Adj.	Reported (3)	Qual Adj. (4)	Reported (5)	Qual Adj. (6)
# Children Loc	0.05	0.05	0.04	0.04	0.25	0.20
	(0.03)*	(0.03)*	(0.03)	(0.03)	(0.11)**	(0.23)
# Oth Adults Loc	-0.01	0.002	-0.008	0.006	0.14	0.15
	(0.02)	(0.03)	(0.02)	(0.02)	(0.10)	(0.15)
Single Adult HH Loc	-0.45	-0.48	-0.54	-0.53	-0.55	-0.65
	(0.30)	(0.33)	(0.36)	(0.38)	(0.40)	(33.40)
# Children CB	-0.006	-0.05	-0.002	-0.04	-0.02	-0.03
	(0.08)	(0.07)	(0.07)	(0.07)	(0.19)	(0.23)
# Oth Adults CB	-0.07	-0.02	-0.07	-0.02	-0.03	0.03
	(0.06)	(0.06)	(0.06)	(0.06)	(0.16)	(0.18)
Single Adult HH CB	-0.27	-0.24	-0.33	-0.25	-0.14	-0.31
	(0.26)	(0.17)	(0.25)	(0.17)	(0.27)	(3.72)
# Children Ind	0.09	0.09	0.10	0.09	0.03	-0.08
	(0.05)**	(0.04)**	(0.04)**	(0.05)**	(0.08)	(0.11)
# Oth Adults Ind	0.09	0.07	0.09	0.07	0.03	0.04
	(0.03)***	(0.03)**	(0.03)**	(0.04)*	(0.08)	(0.18)
Single Adult HH Ind	0.15	0.19	0.16	0.19	0.22	0.15
	(0.24)	(0.22)	(0.23)	(0.22)	(0.27)	(4.52)
κ Local	0.22	0.34	0.17	0.29	-0.09	-0.04
	(0.15)	(0.22)	(0.16)	(0.23)	(0.13)	(0.15)
κ CB	0.05	-0.12	0.06	-0.11	-0.01	-0.16
	(0.13)	(0.11)	(0.12)	(0.12)	(0.14)	(0.12)
κ Indust	0.09	0.02	0.07	0.007	-0.002	-0.06
	(0.21)	(0.17)	(0.23)	(0.18)	(0.20)	(0.19)

*, **, and *** for 10%, 5%, and 1% significance levels, respectively; Standard errors are reported in parenthesis and are robust to correlation at the block level

Table 3.6.10: Income Elasticity

	Market Prices		Quality-Adjusted Prices	
Local	0.67	(0.24)	0.61	(0.24)
Crossbred	0.84	(18.10)	1.03	(14.16)
Industrial	-0.57	(0.37)	-0.35	(0.28)

Standard errors are reported in parenthesis and are robust to correlation at the block level. Elasticities are computed using mean values of the variables of interest.

Table 3.6.11: Unadjusted Education & Expenditure Elasticity

	Market Prices	Quality-Adjusted Prices	Market Prices	Quality-Adjusted Prices
	Education		Expenditure	
Local	0.92	0.73	0.69	0.67
	(0.24)	(0.36)	(0.22)	(0.28)
Crossbred	-3.8	-0.93	8.27	7.65
	(6.96)	(5.14)	(5.14)	(4.56)
Industrial	-1.04	0.09	-1.18	-0.67
	(1.38)	(1.28)	(0.72)	(0.69)

Standard errors are reported in parenthesis and are robust to correlation at the block level. Elasticities are computed using mean values of the variables of interest.

Table 3.6.12: Marshallian Price Elasticity

	Market Prices		
	Local	Crossbred	Industrial
Local	-1.42 (0.33)	0.68 (0.33)	0.39 (0.29)
Crossbred	1.31 (1.27)	-7.42 (1.55)	0.74 (2.71)
Industrial	2.04 (0.85)	1.29 (0.72)	0.79 (1.00)
	Quality Adjusted Prices		
Local	-0.24 (0.29)	0.27 (0.25)	0.25 (0.22)
Crossbred	0.59 (0.90)	0.73 (1.70)	0.33 (2.98)
Industrial	0.76 (0.59)	0.48 (0.68)	0.61 (0.93)

Standard errors are reported in parenthesis and are robust to correlation at the block level. Elasticities are computed using mean values of the variables of interest.

Chapter 4

Consumer Valuation of Safe Traditional Foods

4.1 Introduction

Highly pathogenic avian influenza (HPAI) became endemic to Vietnam after several large outbreaks from 2003-5 (Rushton et al., 2005). In addition to a total of 59 human deaths out of 117 cases as of March 2010 (World Health Organization, 2010), HPAI has caused an estimated $US 200 million of losses to Vietnam's economy. A total of 59.3 million head of poultry have either been killed by HPAI or culled (Burgos et al., 2008). The direct economic cost and magnitude of potential public health externalities of HPAI has made it a priority for policymakers and global decision makers. HPAI is a livestock disease that most directly affects producers and food markets but has global implications–a major influenza pandemic could arise from the evolution of the H5N1 virus that causes HPAI. While this is a low probability event, (Peiris, de Jong and Guan, 2007), the current estimated global economic loss from HPAI is $20 billion and the costs of an influenza pandemic triggered by HPAI are estimated to be $2 trillion (FAO, et al., 2008).

While emerging infectious diseases (EIDs) like HPAI have been increasing over time, at the global level resources to prevent and control EIDs have been concentrated in lower risk areas with higher access to financial and technical resources (Jones et al., 2008). Policies to control HPAI in developing countries like Vietnam face several challenges. Although some poultry production is concentrated geographically or with large producers, the ma-

jority of poultry production is on a small scale and free range by diversified rural farmers. Policies to control the spread of HPAI have largely focused on larger scale production, and have even mentioned plans to phase out small scale production. This has led to free range chicken being less likely to be incorporated into formal supply chains and regulatory mechanisms. However, free range chicken commands a large quality premium and makes up the majority of at-home chicken consumption in urban areas. One way to improve the safety of free range chicken production is market development for safety certified free range chicken. In Vietnam, the magnitude to which consumers value food safety for free range chicken is unknown yet critical for policymakers because markets for safety certified free range chicken could lead to an improvement in production and trading practices that impact risk for HPAI as well as other diseases (Ifft, Roland-Holst and Zilberman, 2009). Results of a field experiment I conducted in Hanoi are used to to consider three key questions related to the safety of free range chicken in Vietnam: (1) what is the willingness to pay for chicken with a safety label; (2) what is the willingness to pay for safety relative to taste characteristics; and (3) what groups are willing to pay more for safety labeling.

This field experiment involved the design and implementation of a certification scheme for safely produced chicken, and used discount coupons to elicit the value for safety labeling as well as taste characteristics. This is unique in that the product being designed involved a "live" product or a type of livestock. Other studies that designed a product, such as infant formula in Masters and Sanogo (2002), typically involve manufactured consumer products. A major challenge for this approach was to convince poultry farmers to modify their production system and to adhere to practices that were proscribed by external certification and safety labeling guidelines. While there are some studies that use coupons or vouchers to elicit preferences for certain product characteristics, my study provided consumers an opportunity to have a choice between coupons and enables direct estimation of trade offs amongst safety and taste characteristics. Field experiments have generally not been able to allow for direct trade-offs between safety and taste. Coupon-based approaches and experiments to value food characteristics in general have been used in formal markets, while this paper expands the range of circumstances where coupons can be used in field experiments and demonstrates that this approach can be used with merchants that are operating in open air markets. A methodology that can be used in informal market environments is useful for addressing policy and development issues in food markets and the

agricultural sector in developing countries.

I find willingness to pay for safety labeled free range chicken in Hanoi is found to be significant, approximately a 10-15% price premium, and that households may trade safety for taste characteristics embodied in variety. I further find evidence that more educated households have a higher inclination to purchase safety labeled chicken, but that their previous choice of chicken breed also did not affect selection of safety labeled chicken. The results indicate that safety labeling could be effective for different varieties of free range chicken, and hence reach a broader market and playing a role in policies related to livestock disease and public health. Further, the magnitude of the potential impact of safety labeling is large. Assuming all chicken purchased over a year by every household in Hanoi would have a safety label, the welfare gain for consumers would be approximately $60 million.

4.2 Background

Food safety issues requires both legislative and voluntary action to improve global health outcomes (Kaferstein and Abdussalam, 1999). Structural changes in the world food system, and in particular the introduction of supermarkets, have led to improved food safety (Unnevehr and Roberts, 2002). However food safety and control of the spread of diseases are major issues confronting traditional supply chains, leading to a debate on appropriate policy measures to address these issues and the welfare of poor participants in traditional supply chains (Reardon and Hopkins, 2006). The emergence of a middle class in developing countries that is increasingly purchasing higher valued food (Senauer, 2006) presents an opportunity for developing safety labeling for traditional food markets. Certification has the potential to improve food safety outcomes (Crespi, 2001) and policy makers need to consider consumer responses to different types of certification or labeling (Caswell and Padberg, 1992), but measuring willingness to pay for food safety labeling in countries with strong traditional food sectors is particularly challenging.

Very few studies to estimate chicken demand or the demand for safe poultry have been undertaken in Vietnam, even after HPAI outbreaks. Of the existing studies related to chicken consumption, few have been used for formal demand analysis (Figuié, 2007; Phan and Reardon, 2007). Ifft, Roland-Holst and Zilberman (2009) used cross-sectional household data collected in 2007 to determine that free range chicken has a positive income elasticity in Hanoi.

Demand for chicken in Vietnam has remained differentiated based on breed. Specially, consumers in Hanoi, the capital of Vietnam, still prefer free-range chicken, and have largely not shifted to the frozen chicken cuts that are sold in supermarkets. Consistent with results by Heiman and Lowengart (2009), taste appears to be the key consideration for chicken purchases in Hanoi. For chicken purchased for home consumption, about 90 to 95 percent is purchased outside of supermarkets, and about 75-80 percent is free range chicken. Free range chicken is considered to be very tasty and commands a premium of up to 100% (Ifft, Roland-Holst and Zilberman, 2009). This is similar to chicken consumption in France, where despite a large premium, 50 percent of all chicken purchases are for Label Rouge chicken, which emphasizes sustainability, food safety and quality (Westgren, 1999). In Vietnam awareness of how different breeds of chicken are raised is high amongst urban households, with consumers correctly linking breed and production environment to desired meat quality characteristics (Ifft et al., 2007).

Demand for free range chicken in urban areas of Vietnam has important implications for policies that address HPAI risk. The production characteristics of free range chicken are different from those of confined (translated from Vietnamese as 'industrial') chicken, with both presenting unique food safety and animal disease risks. Free range chicken is more likely to be exposed to wild birds, while industrial chicken production present risks inherent to concentrated production (Otte et al., 2008). These types of chicken are also produced on different types of farms and marketed through different supply chains (Ifft et al., 2008*a*), necessitating differentiated policies. Improving the safety of free range chicken production can decrease HPAI risk, but the willingness of consumers to support such practices through higher chicken prices is unknown. This paper hence focuses on identifying the consumer valuation of safe poultry production practices.

Studies of consumer behavior suggest that consumer choices are based on quality characteristics (Grunert, 2005), including food safety, which can be communicated by labels or brands (Erdem and Swait, 1998). The model developed by Crespi (2001) showed that voluntary certification for food safety, such as the use of "safety labels", can be effective and efficient in signaling product quality. Several studies have considered valuation of food safety and other health-related characteristics of food (Yeung and Morris, 2001), and there is a large literature on the valuation of food characteristics and safety (for example, Lobb (2005), Lusk et al. (2005), Yiridoe, Bonti-Ankomah and Martin (2007)). The majority of these studies are undertaken in developed

countries and use either retail scanner or experimental data. Experimental methods have largely not been adapted to the unique challenges in developing country settings to value meat characteristics and food safety.

Measuring demand for food safety in developing countries presents unique challenges related to the informality of food markets. Generally data on purchases and prices of food products in markets is rarely collected, which is why most food demand studies utilize household surveys (such as LSMS surveys) and use broad categories of food types, such as beef, poultry and pork (for example, Fang and Beghin (2002); Yu and Abler (2009); Subramanian and Deaton (1996); Golan, Perloff and Shen (2001)). Demand for chicken in Vietnam is differentiated by breed, with free range varieties which are largely sold in traditional markets[1] receiving a large premium. There is generally no free range chicken sold with safety claims (Ifft et al., 2008*a*). However, it is important to assess willingness to pay (WTP) for various characteristics of chicken in order to determine the WTP for safety labeled chicken. Market data on chicken consumption in Vietnam would have allowed for demand analysis with treatment of HPAI outbreaks as a natural experiment, but data on consumption of differentiated products is limited. Most urban Vietnamese households prefer to consume fresh food that is purchased daily in traditional markets near their home (Maruyama and Trung, 2007), where records of sales are generally not kept.

Only a few studies have considered consumer demand for chicken characteristics, generally in developed countries and replying on stated preference methods. Innes and Cranfield (2009) surveyed Ontario consumers and found that the most important chicken characteristics were medication, housing, price and brand. Morkbak and Nordstrom (2009) used a hypothetical choice experiment to determine that Danish consumers have a positive willingness to pay for chicken that is raised outdoors as well as campylobacter-free labeled chicken. Beach and Zhen (2008) found that in Italy media coverage of HPAI outbreaks could lead to decreased chicken consumption for several moths. A stated preference exercise was conducted in Hanoi by Ifft et al. (2007), and found that 75% of survey participants indicated that they would pay at least \$0.75 per kg extra for traceable free range chicken. This indicates a large valuation of safer free range chicken; however, stated preference

[1]Informal markets include "wet" or open air markets where fresh produce, meat and poultry is sold, which characterizes the meaning of 'cho', the Vietnamese word for market. Each neighborhood or ward in urban areas of Vietnam is likely to have its own cho.

methods are limited in that they do not necessarily reflect actual behavior or preferences. List and Gallet (2001) estimated that hypothetical valuation exercises lead to participants on average overstating their preferences by a factor of three. Therefore our study is experimental and involves real trade-offs between discount coupons.

4.3 Literature Review

Field experiments are preferable to other potential methods to measure demand for safety labeled chicken in Vietnam, given that household survey and other data is not sufficient. Field experiments can allow for analysis of revealed preferences through observation of actual choices made by households and control of the conditions under which those choices are made (List, 2009). Harrison and List (2004) define several important areas that distinguish a field experiment, including use of the subject pool and commodity or interest. Of the 3 broad types of field experiments they define, this study is the closest to a 'framed field experiment', because it uses both randomly selected Hanoi households and safety-labeled free range chicken, with participants being aware of the research taking place.

Several laboratory and field experiment methods have been used to value food safety and quality characteristics in developed country settings, generally either through choice experiments or demand revealing auctions, both which ideally involve "real money" and the actual product of interest. Auctions can theoretically induce participants to reveal their true preferences, although in practice multiple rounds often necessary as indicated by Hayes et al. (1996). Hayes et al. (1996) used a multitrial Vickrey auction for measuring demand for several food products with new characteristics. Participants made multiple bids for sandwiches upgrades which they were required both to pay for and eat. Noussair, Robin and Ruffieux (2002) used a similar approach to determine if French consumers value genetically modified organism food labels or lack information. In both papers, new information about the products was revealed in between a series of bids. Sample size for experimental auctions tends to be lower, for example 100-200 participants in the case of Hayes et al. (1996). Auctions can be useful when a product is not available in the market and sample size is limited, and would generally be considered either a framed or artefactual field experiment. A concern with use of some types of auctions is that persistent endowment effects have been found even

over multiple rounds and valuations can vary in different situations (Knetsch, Tang and Thaler, 2001).

Choice experiments can be conducted in the marketplace or a laboratory setting, and are designed to reflect choice situations similar to those encountered naturally in the marketplace. Participants can select between goods, money, or even vouchers for goods. In a laboratory setting, Alfnes et al. (2006) had experiment participants make several choices between salmon alternatives with varying prices and characteristics, of which one choice was binding. These choices were then used to measure willingness to pay for the color of salmon. Lusk, Norwood and Pruitt (2006) recruited experiment participants in a grocery store, and had them select between a discount on their total grocery bill or different types of pork chops, with the results being used to determine valuation of antibiotic-free pork. Corrigan et al. (2009) use a 'open ended choice experiment', where participants select one product from various alternatives and then can decide on the quantity. This approach reflects the choice that consumers face when they are buying goods in the marketplace. Masters and Sanogo (2002) use a choice experiment to find that the economic surplus from certification of nutrient density in infant foods in Malawi is over $1 million annually. In this experiment, women were given infant food and asked if they were willing to trade it for increasing amounts of related products, with only 1 of the choices being randomly selected and rewarded. The key element of these experiments is that participants made trade-offs between goods with different characteristics, and that those trade offs had real repercussions for the participants. In most cases, participants are selecting amongst certification or safety related characteristics or amongst quality related characteristics. It is quite rare that when implemented in the field such experiments allow for direct trade-offs between safety and quality (or taste).

Natural field experiments to value food characteristics are often undertaken when retail scanner or other retail data is available. Kiesel and Villas-Boas (2009) conducted an economic experiment by adding nutrition information labels to microwave popcorn sold at several grocery stores and observing the impact on weekly sales. Shogren et al. (1999) compare results from a retail trial for irradiated chicken breasts with a hypothetical survey and a laboratory auction. The survey and laboratory auction had slightly higher valuation than retail markets (natural field experiment) as expected, but all three approaches showed similar response to changes in price and predicted market share. Shogren et al. (1999) note that although the retail trial was

the most realistic setting to determine revealed preference, the survey and auction allowed for identification of individuals in analysis, as well as other advantages. Methodologies for valuing food characteristics need to be developed to give a clear and robust measurement, while imposing the most realistic conditions for subjects to reveal their preferences. The unique approach developed in this paper was based on the structure of poultry markets in Vietnam, as previous approaches to valuing food safety were not ideal in this setting. Most studies on WTP for food safety are conducted in a laboratory setting, frequently with auctions; however consumers don't buy chicken with auctions but in traditional markets. Our experiment inserted a new product in a traditional market, and used experiments to assess WTP for this new product within the market context.

4.3.1 Field Experiment Design

To measure consumer valuation of safety labeled free range chicken, a non-hypothetical choice experiment was adapted to the circumstances in Hanoi poultry markets. Several poultry and chicken vendors agreed to sell safety labeled chicken (SLC) for a short period, and also to respect coupons for both SLC and non-labeled chickens. Experiment participants were recruited through a household survey, as shopping is undertaken in a very narrow window of time where most shoppers would not have time for an experiment. Household survey participants were given a choice between 2 coupons with randomly determined discounts, 1 for SLC, and the other for regular chicken.

An FAO[2] implemented pilot project for certified supply chain for smallholder[3] chicken in Hanoi (Ifft et al., 2008*c*) was utilized for its supply of the commodity of interest. The SLC were sourced from small farms in a large rural district of Hanoi municipality. Two major types of free range chickens are raised in Vietnam, which are directly translated as 'local chicken' and 'crossbred chicken'. Local chicken refers to native breeds raised on a scavenging diet, while crossbred chicken are native and exotic crosses allowed to scavenge in a garden or confined grazing area with occasional purchased feed. All project chickens were crossbred chickens, as sourcing from 'local' chicken farms would have been too expensive given dispersion and small numbers produced at each farm.

[2]Food and Agricultural Organization of the United Nations

[3]Free range chicken is largely produced by small scale producers, who generally do not have sufficient resources to produce industrial chicken

Each project farm was required to have vaccination for HPAI and other common poultry diseases and follow national safety and environmental regulations for poultry production. These farms were closely monitored by local veterinary officials, which were under the supervision of the district veterinary office. Farms were also randomly visited by an external veterinary inspector as an additional safeguard. Within a week of slaughter, a small but distinguishable tag was put on the foot of each chicken by local veterinarian officials. The tag was designed so it could survive the slaughtering process but if it was removed it could not be reused.

Through coordination with traders, the project chicken was delivered to registered[4] slaughterhouses at a small wholesale market. The slaughterhouses then distributed the chicken to 8 vendors in 4 markets that were already a part of their distribution network. The vendors were supported with training on chicken characteristics and advertising materials. These included posters and brochures describing the production conditions of the chicken and how the chicken could be traced to the farm of origin. Production method and origin have been shown to be effective means of market segmentation based on quality in other countries (Gellynck, Verbeke and Vermeire, 2006). The chicken was distinguishable to consumers by the tag, and also was packaged after sale in a special bag. Vendors were responsible for recording information on all chicken sales before, during and after the testing marketing period, although some struggled with this unfamiliar activity.

An economic experiment was undertaken when the SLC was being introduced. The decision to conduct recruitment through sampling for a household survey instead of in the market was based on shopping habits. Women conduct most of the food shopping in Hanoi, and usually make daily trips to markets to purchase food, so the markets tend to be very crowded and busy for short periods of the day. Directly after working hours shoppers are in a rush to purchase fresh food in time to prepare a meal for their family. Outside of the busy periods, the number of customers is small. Recruiting survey participants in the market would have been difficult due to periodic crowding, and would have also led to a much less representative sample and introduce sample selection bias. Enumerators could visit households at times which were convenient for the participants.

Hanoi has several neighborhoods, all with at least one local market. Each

[4]Very few slaughterhouses in northern Vietnam achieve registration, or government certification

market hence has a 'catchment area' that does not necessarily follow administrative boundaries, with most households in that area using that market. The catchment area for each market was defined through consultations with the market vendors. From this area, blocks were randomly selected and all households in those blocks were listed. Systematic sampling was used to select households within each market area, for a sample of households that would be representative of all households that might regularly visit each market where project chicken was being sold. Out of 1200 selected households, 923 households in total took the household survey and participated in the experiment, which is consistent with high survey participation rates in developing countries. All selected households were visited by enumerators to take a detailed survey about poultry consumption and attitudes that took 20-25 minutes. The enumerators requested to interview the person with primary responsibility for food purchases for the household.

Very few, if any, field experiments have been conducted under situations with a such a high level of informality. This field experiment was designed to take place after the household survey to avoid negotiations for small deviations from average prices between buyers and sellers, which are ubiquitous in Vietnamese markets. We offered individuals a choice between coupons before going to the market to consider their choices independent of price negotiation. Loureiro, McCluskey and Mittelhammer (2002) used a stated preference exercise to determine valuation of eco-label apples, which was followed by an economic experiment that involved giving customers three discount coupons for three types of apples (Loureiro, McCluskey and Mittelhammer, 2003). Although coupons were given for 3 types of apples, the recipients that did redeem a coupon almost all used the coupon for 1 type of apple that was emphasized in the study. The use of coupons was extended in this experiment to have participants select between coupons before redemption. This gave control over participant's choice sets and allowed for directly analysis of the decision made.

The experiment follows the diagram in figure 4.8.1, which shows the structure of each choice, with amount of discount and breed of "non- labeled" chicken being randomized. After the survey, each respondent was offered a choice of 1 of 2 discount vouchers for 2 types of chicken as a gift for taking the survey. Each set of 2 discounts was randomly assigned to each household, with alternative 1 being SLC (crossbred) and alternative 2 either "regular" (no label or brand) crossbred or local chicken. The discounts varied from about \$0.90 to \$1.60, in increments of about \$0.16. Whether the 'regular'

alternative was local or crossbred was randomly assigned independent of discount, with both alternatives to be purchased from the same vendor. The household was told the market price of each type of chicken and was given a brochure[5] explaining SLC before they made their choice. This would be similar to the market, where the same brochure was available for the safety labeled chicken, but other chicken had no advertising or marketing. Both types of chicken had the same appearance. Information can impact behavior during experiments (Hayes et al., 1996), so participants were given no other information than the brochure available in the market. After selection of a discount, the participant was given a coupon with their name, the discount, and the type of chicken. This coupon had to be used within one week.

The choice between 2 types of chicken is not uncommon: local and crossbred chicken together made up about 87% of purchases for chicken to be consumed at home for survey participants and the majority of chicken is not purchased in cuts but is purchased whole. The household survey format had the advantage of having detailed background information on chicken consumption for a representative sample, as well as allowing for testing of the impact of household characteristics on demand for safety labeled chicken. Participants might have been offered the choice of a third option, such as cash or a general discount on food. Due to security issues, enumerators did not carry cash with them while implementing the survey.

Having households make a series of choices is common in experiments (for example, Masters and Sanogo (2002) and Alfnes et al. (2006)). We could have given each participant a choice between 1 of 2 discount vouchers (or coupons), and repeated the exercise several times. The discount voucher given to a participant would have been randomly drawn from the discount vouchers that she had selected. Although such an approach can compensate for a low sample size, explaining this procedure and conducting the series of choices would have added a large amount of time to the survey and experiment, likely increasing complexity and decreasing reliability of our results. Although we have one choice set per participant, our sample size is much larger than in similar experiments. Having one choice can also be considered realistic as Vietnamese households tend to shop every day and buy only enough food for one or 2 meals.

[5]The brochure contained information on how safe production practices were used and verified, the traceability mechanisms, and other general information on production and processing practices that were used.

The decision of presenting the coupon as a discount from total chicken purchase, a per kg discount, or a low(er) price for a chicken purchase was based on the requirements of the FAO certified supply chain project. As a part of their contracts, vendors had to record all prices for all chicken sold, including project chicken. Recording of individual prices and sales was unfamiliar for most vendors, so having a discount coupon that was easy to use and redeem was very important. Vendors could not be given any incentives to misreport prices or quantities, as was the case with the options of a per kg discount or a discounted total price. When presenting the choice to survey participants, they were told the discount for each alternative, and the weekly average market price for that type of chicken.

In this experiment, participants were making a choice under similar information and alternatives than that which was available in the market place at same time; however the novelty of a brand (the safety label) might have motivated them to try to the coupon, and might not reflect behavior under repeated purchases. The framing of field experiments have been empirically shown to have an impact on choice (Lusk, Pruitt and Norwood, 2006), in the context of motivating pro-social behavior. Any single period market test or field experiment is subject to curiosity for a new product, but we also cannot quantify the impact of curiosity versus skepticism. Market vendors from the project reported frequent suspicion of new products by consumers; although many were curious, others wanted to wait and see how others felt about the product. Some consumers might have also distrusted the new chicken, especially if it was to be purchased from an unfamiliar location. We cannot identify these effects, but instead must interpret our results as indicating the current valuation for and interest in safer chicken, not necessarily valuation over the long-term.

4.4 Empirical Model

Utility from food consumption is commonly represented as utility from a set of food characteristics. The household production function of Lancaster (1966) and Becker (1965) is frequently applied to estimate food and nutrition choices. Silberberg (1985) showed that "pure nutrition" takes a smaller portion of the budget as income increase, hence several food characteristics will be relevant when estimating food demand for households with disposable income. Lancaster (1966) and Becker (1965) argue that utility is derived from

characteristics of goods, such as taste and nutrition, as opposed to goods alone. From this framework, utility from a good i for individual j can be defined as $U_{ij} = f(x_j, z_{ij})$, where z_{ij} is a set of characteristics of good of i, and x_j is all other consumption. Their framework suggests that the prices of a good reflect the value of the characteristics embodied in that good. Random utility theory as developed by McFadden (1974) is well suited to Lancaster's characteristics approach. Random utility models are commonly used in discrete choice analysis (Hanemann, 1984), with utility as a function of set of observed characteristics and a stochastic component that represents unobserved factors that enter the utility function.

In addition to price, taste and safety are key characteristics of meat that enter consumers' utility functions. Foster and Just (1989) show that the likelihood of purchasing food will decline as consumers' perception of food safety declines. Structural changes in the world food system over the last decade have created incentives for improved food safety in developing countries (Unnevehr and Roberts, 2002). A study by Rimal (2005) indicated that 80% of consumers desired meat labels that described production processes. Taste is a driving factor in consumer food decisions, and can even override safety-related information in some cases (Heiman and Lowengart, 2009). As previously discussed, in Vietnam taste considerations are largely related to the breed of poultry, which should also enter the utility function for chicken.

By conducting a field experiment, the characteristics of goods that are offered to consumers are controlled or randomized. The choice that each household made between types of chicken can be modeled in the context of its impact on utility, where utility is a function of consumption of chicken characteristics and consumption of all other goods. We treat the price of all other goods as unity and denote expenditure (or income) as Y_j . Each household has a discrete choice between 2 types of chicken, c_1 and c_2. Each chicken choice i for consumer j has a price of p_{ij} , discount of d_{ij} and a vector of characteristics $z(c_{ij})$. Unobserved variation in the factors affecting an individual's utility is denoted as ε_{ij}, and is assumed to be distributed extreme value and of zero mean. When presented with a choice between consuming 2 types of chicken, each household then faces the following utility maximization problem when we assume that 'no chicken' is not an option:

$$\underset{c_i}{\text{Max}}\ U_{ij} = f\left(z(c_{ij}), \left(Y_j - p_{ij} + d_{ij}\right), \varepsilon_{ij}\right)$$

Other than the chicken characteristics defined in our experiment, which were discount, price, safety labeled chicken, and breed, no other differences in

characteristics could be discerned by the participant. For choice of chicken i, if we assume utility to be linear and separable in chicken characteristics and other expenditure, the household's utility would be: $U_{ij} = \beta z(c_{ij}) + \delta\left(Y_j - (p_{ij} + d_{ij})\right) + \varepsilon_{ij}$, with β and δ being vectors of coefficients that represent the relative share of each characteristic in utility. Chicken characteristics (c_i) in this experiment are safety labeled chicken (s_i), and taste or variety (v_i, local or crossbred) of chicken. Because discount, safety, price (vendor) and variety were randomly assigned, we assume that the error term or unobserved variation in utility is not correlated with our observed characteristics, or $\mathbb{E}(\varepsilon_{ij} z_i) = 0$ for observed characteristics. All variables are exogenous by design, so our empirical analysis with not be impacted by endogeneity problems persistent in random utility analysis of market data (Villas-Boas and Winer, 1999).

From this framework we can use a logit model to estimate the price and characteristics coefficients and valuation for safety labeling and variety (Train, 2003). If a participant j has 2 choices, she will pick option i over option k if $\beta_1 s_{ij} + \beta_2 v_{ij} + \delta_1 d_i - \delta_2 p_{ij} + \delta_3 Y_j + \varepsilon_{ij} > \beta_1 s_{kj} + \beta_2 v_{kj} + \delta_1 d_{kj} - \delta_2 p_{kj} + \delta_3 Y_j + \varepsilon_{kj}$, or $\varepsilon_{ij} - \varepsilon_{kj} > \beta_1(s_{ij} - s_{kj}) + \beta_2(v_{ij} - v_{kj}) + \delta_1(d_{ij} - d_{kj}) - \delta_2(p_{ij} - p_{kj})$. The difference in errors has a logistic distribution, which is a well-established property of these models. We then know that the probability of picking alternative i for individual j is $P_{ij} = \frac{\exp(\beta z_{ij})}{(\exp(\beta z_{ij}) + \exp(\beta z_{ij}))}$, where we have simplified β as a vector of all coefficients, and z as a vector of all characteristics.

From logit estimation we can easily estimate willingness to pay (WTP), or compensating variation (CV), for specific characteristics. We use the interpretation of WTP over willingness to accept (WTA) because households were constrained by their budget in their use of the discount coupon. From our random utility model, compensating variation of healthy chicken can be defined as C s.t. $U(s = 0, d) = U(s = 1, d - C)$, which gives $C = \frac{\beta_1}{\delta_1}$ for chicken of the same variety and price. This follows the general interpretation of welfare from the parameters of logit models (Louviere, Hensher and Swait, 2000). We use WTP as the most realistic interpretation of potential gains given the choice that households made, but recognize the functional form we use for estimating utility has no income effects and hence admits the same welfare measurement for equivalent variation (WTA) and even consumer surplus (Hanemann, 1984).

Treatment of how prices and discounts enter the utility function is a specific concern in our analysis. The marketing literature has several examples

of how consumers react differently to discounted prices, actual prices and actual discounts. Guadagni and Little (1983) find that both discounted price and advertised percent discount impact product choice, but the impact of a promotional price cut is higher than the actual promotional price. Previous consumer experiments have shown that coupons for brands are valued more and that more generally framing of discounts or promotions can have an impact on coupon valuation (Krishna et al., 2002). The concern that discounts for safety-labeled or local chicken have a greater value can be tested by interacting safety labeled chicken and local chicken with discount and estimating these interaction terms with our logit model. These interaction terms allow for testing that for chicken with characteristic j discount enters utility as $\delta_1 d_{ij} + \gamma d_{ij}$, while for chicken with characteristic k discount enters utility as $\delta_1 d_{ik}$. If the interaction variables have a statistically significant impact on choice or improve the fit of the model, then the WTP estimate would be biased.

A related concern in the marketing literature is different valuation of price and discount, which is consistent with prospect theory (Kahneman and Tversky, 1979). In experiments prospect theory has been shown to be more relevant to inexperienced individuals or during a single period transaction (List, 2004), which applies to our experiment with one choice situation and a new product. Prospect theory defines a decision process over two stages, editing and evaluation. In the editing stage, information available to the decision-maker is framed to simplify the computation or decision. Several empirical studies have shown old or common information is often ignored, which would apply to existing market prices which were reported to participants before they selected a discount coupon. (Kahneman and Tversky, 1979) also cite studies showing cognitive factors can affect framing, which in this study could have led participants to focus on discounts instead of making a mental calculation of net prices. Another prediction of prospect theory is that people emphasize what can be gained in the present. At the time of the experiment, participants were receiving a coupon to purchase discounted chicken, so the discount might have been emphasized.

If survey participants do treat price and discount differently, the appropriate utility representation would be with utility representation $U_i = \beta z(c_i) + \delta_1 d_i + \delta_2 p_i$ (Specification 2), as opposed to $U_i = \beta z(c_i) + \delta(p_i - d_i)$ (Specification 1). Specification 1 would be consistent with fully rational behavior. We can observe the effect of prices on household choices from our estimation and also conduct hypothesis tests using likelihood ratios to see if treating prices

as equivalent to discount in our model improves goodness of fit. Another alternative specification to be tested would be $U_i = \beta z(c_i) + \delta_1 d_i + \delta_3(p_i - d_i)$ (Specification 3), which would indicate when selecting chicken participants were considering both discount and discounted price, but with different utility weights. Prices of chicken had almost no variation across participants who lived in the same neighborhoods, hence we will not be able to empirically distinguish between behaviors predicted by prospect theory and low variation of prices. However, both would lead to underestimation of consumer valuation of safety-labeled chicken, as δ_2 would be lower than in reality, or statistically insignificant. In either case, results could be interpreted in the context of lower weights on prices.

Our analysis will be undertaken for the choice of a coupon, not for the choice to redeem the coupon. By selecting a coupon, experiment participants are selecting an option to buy a chicken at a discounted price at a future date. Given endogeneity associated with price negotiation in markets and unobservability of the choice set at the time of redemption, valuation of safety labeled chicken cannot be determined from the choice to redeem or not redeem. The coupons had to be redeemed within one week; a shorter time frame would have been difficult because most households do not eat chicken more than 1 time per week. The choice to redeem would have been based on transaction costs that would be different over individuals, for example the cost of buying chicken from an unfamiliar vendor or from a more distant market.

Our measure of value of safety labeled chicken is a measure of willingness to receive a lower discount for certification (if the coupon was redeemed). Hypothetical choice experiments have been shown to have a much lower bias than most stated preference exercises, and no bias for marginal willingness to pay measurements (Lusk and Schroeder, 2004). The discount coupon selected in this experiment was not hypothetical, but there was an option to redeem or not redeem. A major problem with stated preference exercises is that desirable characteristics are over-valued, given that participants don't have to make any commitment of their own money or resources. In this experiment, a higher discount would have been a "desirable characteristic", and hence any bias would be downwards. Although safety labeled chicken and local chicken are desirable characteristics, a higher discount coupon could be gained instantly by participants. The design of the experiment addresses many challenges of implementing a field experiment in a situation with price negotiation and informality, while also mitigating the upward bias of valua-

tion associated with hypothetical experiments.

Many of the disadvantages of a logit are related to independence of irrelevant alternatives (IIA) and panel data with correlation in factors not observed by the researcher. Given that this experiment only had two alternatives and 1 choice situation, these issues are not relevant. Use of a mixed logit would allow for estimation of taste variation across individuals, but initial analysis of our data indicated that the number of alternatives or individual choice situations was too low for effective mixed logit estimation. Logit analysis hence is an acceptable approximation for average tastes (Train, 2003). However, household characteristics can be added to the model to improve precision of estimates as well as indicate which groups have higher demand for safety.

Several studies have shown that demographic and socioeconomic factors can impact demand for food safety as well as other food characteristics (for example, Heiman, Just and Zilberman (2000), Gould, Cox and Perali (1991)). Heiman et al. (2001) find these type of household characteristics play a large role in determining meat demand in Israel. Various household characteristics (x) can be added our to utility function by interactions with our variables of interest. We are most interested in valuation of safety, so we interact s with x for the following specification: $U_{ij} = \beta_1 s_{ij} + \beta_2 v_{ij} + \beta_3 (s_{ij} \cdot x_j) + \delta_1 d_{ij} - \delta_2 p_{ij} + \delta_3 Y_j + \varepsilon_{ij}$. This model will indicate which demographic factors and attitudes would increase utility from safety-labeled chicken. Individual household characteristics will be tested with our basic empirical specification, as well as a more general specification that includes several characteristics that impacted household choices. Previous behavior is also of interest as habits have been shown to influence food demand (Blanciforti and Green, 1983), so we will also test the impact of previous chicken consumption on choices made during the experiment. Willingness to pay for safety is $\frac{\beta_1 + \beta_3 x_j}{\delta_m}$, where δ_m is the contribution of money (price or discount) to utility.

4.5 Summary Statistics

The majority of survey participants were relatively affluent and well-informed women. 92 percent of participants were women, and 63 percent were employed at least part time. 64 percent of all households surveyed had at least 1 member with a university education. Average annual per capita food expenditure of $890 was roughly equivalent to the per capita gross national income in 2008 in current US$ (World Bank, 2011*b*), indicating the partic-

ipants were in the middle to high income brackets in Vietnam. 67 percent of participants had received information on HPAI within the past 6 months, and less than 5 percent of the sample answered basic questions about safe poultry handling incorrectly. Other household characteristics used in our analysis can be found in table 4.8.8.

Previous consumption choices are summarized in table 4.8.1 and indicate a strong preference for free range chicken purchased in traditional markets. These habits confirmed our choice of experimental design, especially to have SLC that was being sold in traditional markets. Each respondent was asked several questions regarding the last 3 times they had consumed chicken. Not all respondents could recall 3 occasions, so we have a total of 1,616 chicken consumption observations. About 75 percent of all chicken consumed is a local breed, with the remainder split equally between industrial and crossbred chicken. 40 percent of all local chicken is purchased live[6], while for crossbred and industrial chicken a higher level of processing is more common. Local chicken is more likely to be purchased from an informal source, and less likely to have government inspection or be sold by a company. 54 percent of households reported never purchasing food from supermarkets, and only about 5 percent of chicken was purchased at a supermarket. Per capita weekly chicken consumption is about 0.25 kg.[7]

Slightly over half of all households had crossbred chicken as their variety of 'regular' (no safety label) chicken; although the varieties were randomly assigned there was some variation based on availability of breeds at specific project vendors. Average prices and standard deviation of prices of the 3 types of chicken offered can be found in table 4.8.2. Local chicken is the most expensive, while crossbred was the cheapest. Crossbred and safety labeled chicken had the most variation in price. The average discount was $US 1.25, with a standard deviation of $US 0.22.

The choices that survey participants made based on level of discount are summarized in table 4.8.3. In table 4.8.3, we can see that households selected safety labeled chicken 91% of the time when the alternative was crossbred, and 65% of households safety labeled chicken when the alternative was local chicken, when the same discount was offered for each alternative. Likewise, when the discount for safety labeled chicken was 2,500

[6]Selling of live chicken in Hanoi has been illegal since initial HPAI outbreaks but is still common

[7]Categories in this table overlap, so each row will total to more than 100. For example, chicken that is purchased from a company might also be in cuts.

Vietnamese Dong (VND) larger than crossbred chicken, 96% of household selected project chicken, while 85% of households selected project chicken when the alternative was local. 2,500 VND is about $US 0.17.

We can see that households responded to increasing levels of discount, and when there was no "taste trade-off" between local and crossbred chicken, households were more willing to pay for safety. However, the local chicken alternative was considered more valuable than the crossbred alternative (the safety label was only available for crossbred chicken), which indicates that some households were willing to sacrifice taste for safety. This finding is not inconsistent with the literature. Heiman and Lowengart (2009) show that a significant amount of negative health information is necessary to overcome preferences for taste. A study that used an experimental auction methodology by Combris et al. (2007) showed that sensory attribute of fruit related to taste are given more weight than food safety guarantees. Meuwissen and van der Lans (2004) showed that food safety is considered the most important attribute of pork when no trade-offs are considered, but that once trade-offs are considered taste becomes a major concern.

These experimental results offer a significant departure from previous chicken consumption. 75% of households are regularly choosing to consume local chicken over crossbred or other options. Crossbred chicken is considered slightly less tasty than local, but on average is more than $0.50 per kg cheaper. The presence of a brand and safety claims led many households in our study to select crossbred instead of local chicken. Credible labeling that led to increased prices was attractive even to households that are used to purchasing live local chicken from informal sources.

4.6 Results

Results of estimation of our model with specifications 1-3 for price and discount using a logit model can be found in table 4.8.4. A safety label appears to have a consistent effect across all specifications, as does local breed. We observe that all coefficients other than price in specification 1 and 3 have a statistically significant effect at the 1% level. The price coefficients across all three specifications are also of a low magnitude relative to other explanatory variables. We use the results from specification 1 and 2 to test the null hypothesis that $\delta_1 = \delta_2$, or that discount is given the same weight as price by experiment participants. In other words, we are testing if a $1 difference in

discount is equivalent to a \$1 difference in prices. If $\delta_1 = \delta_2$, then the data will better fit specification 1. We use a χ^2 test and compare the ratio of log-likelihoods of each specification based on (Train, 2003) and strongly reject that $\delta_1 = \delta_2$. Given this difference, it is not appropriate to treat discount and price effects the same in welfare estimation. Hypothesis testing further indicates that we cannot determine if Specification 2 or 3 is a better fit for the data. Specification 2 will be used in all estimation from this point unless otherwise noted, as it is more parsimonious.

Coefficients from logit estimation are not interpreted individually, as the valuation of a characteristic is the ratio of the characteristic coefficients and price coefficient (Train, 2003). Given differential valuation of prices and discount and statistically insignificant price effects, incorporating prices coefficients into calculation of WTP would lead to biased estimates. Alternatively, the WTP for healthy chicken with a lower discount can be considered a lower bound on WTP safety labeled chicken. An upper bound would be the WTP for a discount in addition to the existing price differential between safety labeled crossbred chicken and regular crossbred. Breed must be held constant, and we use crossbred as our base breed because safety labeled local chicken was not available. The upper bound assumes that households treat the discount the same as price as would be predicted by utility theory, or that their behavior is "rational". Although we have no evidence for such behavior, we illustrate the upper bound by assuming that prices have some impact on choice but their effect cannot be empirically captured by the household's choice. WTP in this case would be C s.t. $U(s=0,p|\text{variety=crossbred}) = U(s=0,p-C|\text{variety=crossbred}) \rightarrow -\delta_2 p_i = \beta_1 - \delta_1 C - \delta_2 p_k \rightarrow C = \frac{\beta_1 - \delta_2(p_i - p_k)}{\delta_1}$. If we assume $\delta_1 = -\delta_2$, then $C = \frac{\beta_1}{\delta_1} + (p_i - p_k)$. This is our upper bound estimate, which assumes that prices would never have a greater contribution to utility than discount, or $\delta_1 \geq -\delta_2$. We must also assume that the price of safety labeled chicken is at least as high as than the price of regular chicken, which is consistent with our data. For $\frac{\beta_1}{\delta_1}$ to be a lower bound estimate, we make the assumptions that (1) $\delta_1 \geq 0$, or that households do not dislike discounts and that (2) $\delta_2 \leq 0$, or households do not like higher prices. Actual WTP would likely be between these 2 estimates, as we expect prices to have some impact on utility, but at a lower weight than discount. The same argument applies to the upper and lower bounds to WTP for local chicken, or for taste.

Results for valuation of safety labeled chicken can be found in table 4.8.5,

and are calculated from the results reported in column 1 of table 4.8.4. As indicated in column 1 of table 4.8.5, the lower bound WTP calculated from the safety label is \$0.50 and is statistically significant at the 1% level[8], and the lower bound WTP a local breed is \$0.36 and is statistically significant at the 5% level. Average prices for crossbred chicken, project chicken, and local chicken at the time of the study as reported to survey participants respectively were \$4.59, \$5.13, and \$6.14. Given that the price differential for a whole bird (as observed in the market and reported to experiment participants) between regular crossbred chicken and crossbred chicken with a safety label is \$0.54, we add that differential to the WTP, which indicates an upper bound valuation of safety labeling of about \$1.04 per chicken purchase. We interpret \$1.04 as an upper bound, with \$0.50 as a well-identified lower bound on the valuation of safer chicken. Likewise, the upper bound valuation for local chicken would be \$1.90.

Marginal effects measure the change in probability that an alternative will be selected given the characteristic is present (or increases by one unit, if not an indicator variable) and are reported in column 2 of table 4.8.6. A chicken with an increase in discount of one dollar had 0.63 higher probability of being selected, and a chicken that was a local breed would have a 0.23 higher probability of being selected. The discount elasticity reported in column 3 is analogous to price elasticity of demand: a discount elasticity of 1.03 for safety labeled chicken indicates that a 1% increase in discount for safety-labeled chicken is associated with a 1.03% increase in selection of safety-labeled chicken. As local breed is an indicator variable, we do not report discount elasticity for local breed.

In Table 4.8.7, we estimate three specifications that give insight into potential biases of participants. We first interact the characteristics and discount variables to test for different weighting of discounts for different characteristics. The coefficients on each interaction variable found in columns 1-2 of table 4.8.7 are of small magnitude and not statistically significant, which indicates discounts were not weighted differently for safety or taste (local breed) characteristics. The variable 'discount squared' used in regression 3 is not statistically significant, and hence provides no evidence that utility weights given to discount are non-linear. Overall, we see no evidence of bias related to differential valuation of the discount and chicken characteristics or

[8]All standard errors for WTP in this paper are calculated using a cluster bootstrap with 3000 iterations

non-linearities in valuation of discount.

A total of 65 households redeemed the coupon that they had selected. This number was lower than expected, with several possible reasons. Very few households reported consuming chicken more than one time per week. The "expiration" of the coupon was one week, which might not have given enough time for redemption. During experiment design, one week was considered to be a relatively long period, given potential for sharing of the coupon and desire for households to reveal their preferences for (relatively) immediate consumption. The experiment might also have been restricted by the number of vendors involved in the FAO project. Each market (cho) usually has several poultry vendors, and only 2-3 in each market were involved in the project. Of all chicken purchases reported by project participants, 96 percent were from a vendor or location that they regularly use. These close relationships between consumers and vendors are common at all stages of the poultry supply chain (Ifft et al., 2008*b*). Negotiating with an unfamiliar vendor might have added a transaction cost that decreased the likelihood of redeeming the discount coupon. Furthermore, the price of live local chicken was $4.80 per kg, which was cheaper than the average prices for slaughtered chicken that the coupons could be redeemed for. Given preferences for local breeds, the discount again might not have been large enough to overcome the transaction cost of buying from a new vendor. If this experiment design is replicated, many of these issues could be addressed and more attention should be given to the likelihood of coupon redemption. In this experiment, extensive testing was limited by the short timing of the FAO project.

As previously stated, this approach to a field experiment not only introduces actual money in the form of a coupon and uses the product of interest, but likely reverses the direction of any potential bias from having use of a coupon be optional as opposed to mandatory. This idea is borne out in the data. When logit estimation is restricted to households that redeemed a coupon, the lower bound WTP for a safety label is $0.81, and is statistically significant at the 5% level. This results supports the proposition that households that were less certain of coupon redemption would have focused on receiving a higher discount, which leads to lower estimated valuation of safety. This result also supports the robustness of our main result as a lower bound WTP for safety labeling.

4.6.1 Impact of Household Characteristics

Household characteristics, or the heterogeneity between households, can impact preferences for safe chicken. We add heterogeneity to our estimation by adding various household characteristics to our utility function and empirical specification that are interacted with the safety label indicator variable. These variables were each individually estimated with our logit model, with results summarized in table 4.8.8. The left column describes each variable, the middle column is the mean of each variable, and the right column gives the coefficient (β_3) and its standard error from the logit estimation. Each coefficient can be interpreted as the relative share of utility from consuming safety labeled chicken corresponding to the level or presence of a characteristic. The magnitude of the coefficients on household characteristics are small relative to those of chicken characteristics reported in table 4.8.4, although based on the results in table 4.8.8 several households characteristics have a significant impact on demand for safety.

In table 4.8.9, we add multiple characteristics and consumption habits to our model based on the results from table 4.8.8, with an objective of improving goodness of fit while maintaining parsimony. Some of the characteristics that were individually statistically significant no longer impacted demand for safety when estimated with other characteristics. This is demonstrated in column 1 of table 4.8.9, which is labeled "Example", as multiple specifications were tested. Specifically, the impact of chicken consumption, number of children under 10, expenditure eating outside of the home, local chicken purchases, and processed chicken purchases have effects that are not statistically significant when other characteristics are controlled for. Several different combinations of characteristics were added to the model and estimated before determining the "final model" shown in column 2 of table 4.8.9. Education, brand certification, trust of market inspectors and purchase of government certified chicken appear to have the largest (and most stable) influence on demand for safety labeled chicken.

Concern for HPAI has a small positive impact, while concern for the source of chicken has a negative sign, but these variables are not statistically significant. This might indicate that valuation of safety labeled chicken is related to safety concerns other than a desire to know exactly what farm a chicken came from or HPAI status. Further, purchasing higher levels of live chicken, local chicken, processed chicken and chicken supplied by a company have no statistically significant impact on preferences for safety labeled

chicken once other characteristics are controlled for. Overall these results indicate that habits and attitudes related to chicken consumption are less important than experience with certification.

Households with a higher level of trust in their local (government) market inspector were less likely to prefer safety labeled chicken, which implies that low trust in local institutions increases demand for guarantees of safer chicken. Households were asked for their level of trust in varies entities, such as: companies, the Department of Animal Health, and their local market vendors. Local market inspectors had the lowest score, while international companies and local market vendors were the most trusted entities. This is consistent with results from a study of Greek consumers by Krystallis and Chryssohoidis (2005) that showed that willingness to pay for organic foods increased with trust of certification. In this study, trust of government inspection appears to be a substitute for additional certification. On the other hand, households that purchased government inspected chicken had a higher valuation of safety labeling. Purchasing government inspected chicken indicates either (1) households value government certification or (2) households that prefer to shop at the relatively more hygienic markets where inspection is common but would like a substitute for government certification or additional certification. Given the overall low trust in market inspectors and vendor reports that consumers don't trust government certified chicken, the later explanation is more likely and corresponds to our other findings. Private or external safety certification of chicken seems to be an attractive option or substitute for households who have attitudes or behavior that shows such a demand for better certification.

The result that education increases valuation of healthy chicken is consistent with the role of information and wealth in information food consumption decisions. In a study of English consumers, Yeung and Yee (2003) find that education plays a key role in consumer strategies to address microbiological food safety risks in chicken. Educated households might have more knowledge of risks or more interest in purchasing safer food, as well as significantly higher incomes. Education is strongly correlated with incomes in Vietnam.

Concern for brand purchases has a negative and significant coefficient, but might just indicate that preference for brand purchases in other areas is not related to chicken. Given the extremely low magnitude of this coefficient, further interpretation is unnecessary. Concern (or preference) for brand purchases was asked for 5 categories: cosmetics, appliances, liquor, clothes, and vegetables and the variable used in estimation is an aggregation

of those rankings.

WTP for safety labeling that takes into account household characteristics has a lower bound of $0.54 and an upper bound of $1.08, which is very similar to the WTP in the model without household characteristics. Table 4.8.10 shows the standard errors of WTP for safety using the model found in column 2 of table 4.8.9. Because WTP is similar under estimation with and without heterogeneity, it is interesting to see the relative magnitude of each characteristic on demand for safety. Table 4.8.11 shows the marginal impact of an increase of 1 unit of each characteristic on the likelihood of a household selecting safety labeled chicken in the experiment. Education and purchases of government certified chicken have the largest impact on selecting safe chicken, while trust in market inspectors and brand preferences have a much smaller impact.

4.7 Conclusion

This paper presents a novel methodology for a field experiment using coupons that shows a significant willingness to pay for safety labeled free range chicken in Hanoi, approximately a 10-15% premium. Through developing a new variety of chicken that was both free range and safety labeled, we implemented a field experiment that addresses many of the challenges of valuing food characteristics in developing country settings. We found evidence that more educated households are interested in safety labeled chicken, which supports the proposition that demand for safer chicken will increase as incomes and education grow in Vietnam. The previous choice of chicken breed also did not affect selection of safety labeled chicken, which was always crossbred. This result indicates that safety branding could be effective for different types of free range chicken, and hence reach a broader market.

These results show that one potential way to address HPAI and other food safety and environmental issues is through market based incentives for farmers to adopt new practices. This approach might be considered as a viable means for 'payment for health and environmental services'. Developing a market for safety labeled free range chicken might be challenging from a supply side perspective, but consumer demand will not be a barrier to market-based approaches to improve the safety of poultry production and handling practices for free range chicken. Future research presents two major challenges, including designing supply chains that deliver 'health services' in

developing countries, and measurement of willingness to pay for health and environmental services in a realistic setting. The research and development agenda to develop market based solutions to environmental and public health problems is ongoing and should be expanded. The methodology in this paper can be used in both developed and developing country settings to show where such markets are appropriate.

4.8 Tables and Figures

Figure 4.8.1: Experimental Design

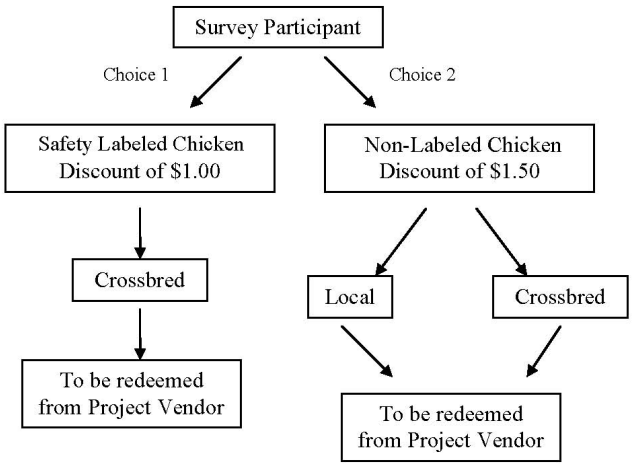


Table 4.8.2: Average Chicken Prices for Project Vendors, per Kg

	Mean	Std. Deviation
Safety Labeled Chicken (Crossbred)	US$ 5.13	US$ 0.72
Regular Crossbred Chicken	US$ 4.59	US$ 0.53
Regular Local Chicken	US$ 6.14	US$ 0.21

Table 4.8.1: Previous Chicken Consumption Characteristics

Breed	N*	Price	% Purchased Live	% Purchased in Cuts	% Purchased from Informal Sources	% with Stamp or Govt. Inspection	% Supplied by a Company
Local	1220	$5.21	41%	8%	88%	22%	5%
Crossbred	195	$4.51	17%	43%	64%	19%	36%
Industrial	201	$3.57	3%	87%	81%	36%	27%

*Survey participants reported up to 3 occasions of previous chicken consumption, so the number of observations is greater than the number of survey participants

Table 4.8.3: Percent of Households Selecting Safety Labeled Chicken by Breed of Non-Labeled Alternative

	Crossbred Alternative		Local Alternative	
Difference in Discount*	Percent	Obs.	Percent	Obs.
<-2,500 VND	57%	112	28%	98
-2,500 VND	70%	77	39%	66
Same Discount	91%	89	65%	83
2,500 VND	94%	84	71%	62
>2,500 VND	96%	129	85%	87
Total	82%	491	57%	396

*Discount for safety labeled chicken less the discount for non-labeled chicken

Table 4.8.4: Conditional Logit Model Results

	Specification 1	Specification 2	Specification 3
	(1)	(2)	(3)
Discount		3.471***	3.523***
		(.678)	(.717)
Price		.052	
		(.215)	
Price Less Discount	-.350		.052
	(.260)		(.215)
Safety Label	1.719***	1.722***	1.722***
	(.279)	(.318)	(.318)
Local Breed (taste)	1.378***	1.258***	1.258***
	(.368)	(.408)	(.408)
Obs.	1774	1774	1774
Log-Likelihood	-499.918	-428.204	-428.204

*, **, and *** for 10%, 5%, and 1% significance levels, respectively; standard errors are robust to correlation at the block level

Table 4.8.5: Valuation of Chicken Characteristics

	WTP Lower Bound	WTP Upper Bound	SE
Safety Label	0.50***	1.04	(0.174)
Local Breed	0.36**	1.90	(0.181)

*, **, and *** for 10%, 5%, and 1% significance levels, respectively; standard errors (SE) are calculated using a cluster bootstrap with 3000 iterations and are robust to correlation at the block level

Table 4.8.6: Marginal Effects (ME) and Elasticities

		SE^{+}
ME: Discount	0.63	0.144
ME: Local Breed (Taste)	0.23	0.083
Elasticity: Discount	1.03	0.272

*, **, and *** for 10%, 5%, and 1% significance levels, respectively; standard errors (SE) are calculated using a cluster bootstrap with 3000 iterations and are robust to correlation at the block level

Table 4.8.7: Tests for Behavioral Biases

	Taste	Safety	Linearity
	(1)	(2)	(3)
Discount	-3.453***	-3.511***	-2.300
	(.693)	(.686)	(3.498)
Price	.052	.052	.054
	(.213)	(.214)	(.215)
Safety Label	1.720***	1.820*	1.720***
	(.320)	(.959)	(.318)
Local Breed	1.172	1.258***	1.256***
	(1.048)	(.410)	(.406)
Local Discount Interaction	-.066		
	(.741)		
Healthy Discount Interaction		.078	
		(.648)	
Discount Squared			.468
			(1.286)
Obs.	1774	1774	1774
Log-Likelihood	-428.198	-428.193	-428.155

*, **, and *** for 10%, 5%, and 1% significance levels, respectively; standard errors are robust to correlation at the block level

Table 4.8.8: Impact of Household and Consumption Characteristics

Description of Variable	Mean	Coefficient (SE^+)
Concern for chicken flavor (scale of 1-10)	7.2	-0.009(.065)
Concern for chicken origin (scale of 1-10)	7.4	-0.120(.105)
Concern for avian flu (scale of 1-10)	8.3	0.060(.078)
Previous purchase of private-branded chicken	0.58	-0.076(.366)
Weekly chicken consumption, kg	0.83	-0.175(.132)
Age of survey participant	47	-0.005(.008)
Participant is employed	0.63	-0.085(.208)
Participant recently exposed to HPAI information	0.67	0.125(.314)
Participant incorrectly answered basic HPAI questions	0.23	-0.179(.261)
Participant had previously heard of project chicken	0.07	-0.115(.345)
Participant regularly shops at project chicken market	0.55	0.233(.299)
Concern for branding (scale of 1-10, for 5 products)	29.57	-0.044(.017)***
Education level (1-5: 1=primary, 5=university)	3.3	0.310(0.220)
Enumerator appraisal of wealth level (Scale of 1-5)	2.8	0.028(.145)
Trust in Market Inspector (Scale of 1-10)	5.28	-0.194(.058)***
Number of children under 10	0.60	0.187(.134)
% of household members under 23 years old	0.33	-1.001(.573)*
No change in food purchases due to inflation	0.61	-0.122(.260)
Number of supermarket trips per month	0.89	0.001(.076)
% of food expenditure spent for eating out	0.28	-2.718(1.164)**
Meat consumption per capita, $US	7.22	0.048(.057)
Weekly per capita food expenditure, $US	17.60	0.010(.026)
% Chicken Purchased: Local Breed	0.77	-0.407(.296)
% Chicken Purchased: Live	0.35	-0.050(.270)
% Chicken Purchased: Processed	0.20	0.645(.295)**
% Chicken Purchased: Government Certified	0.25	0.699(.303)**
% Chicken Purchased: Sold by a Company	0.11	0.070(.375)

*, **, and *** for 10%, 5%, and 1% significance levels, respectively; standard errors (SE) are robust to correlation at the block level

Table 4.8.9: Logit Estimation with Heterogeneity

	Example	Final Model
	(1)	(2)
Discount	3.658***	3.586***
	(.745)	(.334)
Safety Label	2.394***	2.111***
	(.872)	(.585)
Local Breed (taste)	1.311***	1.298***
	(.406)	(.199)
Price	.134	.117
	(.220)	(.118)
Chicken Consumption, kg	-.161	
	(.124)	
Preference for Brands	-.032*	-.042***
	(.017)	(.013)
Household Education Level	.479*	.465***
	(.256)	(.156)
Trust in Market Inspector	-.140**	-.143***
	(.066)	(.045)
Number of Children under 10	.172	
	(.126)	
Percent Expenditure Spent Eating Out	-1.539	
	(1.049)	
Percent Local (Breed) Chicken Purchases	-.252	
	(.332)	
Percent Processed Chicken Purchases	.122	
	(.356)	
Percent Govt. Certified Chicken Purchases	.488**	.555**
	(.237)	(.245)
Obs.	1692	1706
Log-Likelihood	-384.069	-388.801

*, **, and *** for 10%, 5%, and 1% significance levels, respectively; standard errors are robust to correlation at the block level

Table 4.8.10: WTP with Heterogeneity

	WTP (Lower Bound)	WTP (Upper bound)	SE*
Local Breed (Taste)	$0.36	$1.90	0.177
Safety Label	$0.54	$1.08	0.208

*Standard errors are calculated using a cluster bootstrap with 3000 iterations and are robust to correlation at the block level

Table 4.8.11: Marginal Effects of Household Characteristics

	Marginal Effects	SE*
Discount	0.616	(0.153)
Local Breed	0.229	(0.083)
Trust in Market Inspector	-0.025	(0.011)
Education	0.080	(0.041)
Brand Preference	-0.007	(0.003)
% Govt Certified Purchases	0.095	(0.042)
Obs	1706	
Log-Likelihood	-388.801	

*Standard errors are calculated using a cluster bootstrap with 3000 iterations and are robust to correlation at the block level

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