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The Impact of HPAI Outbreaks on Revenue and Wealth: An Analytical Framework

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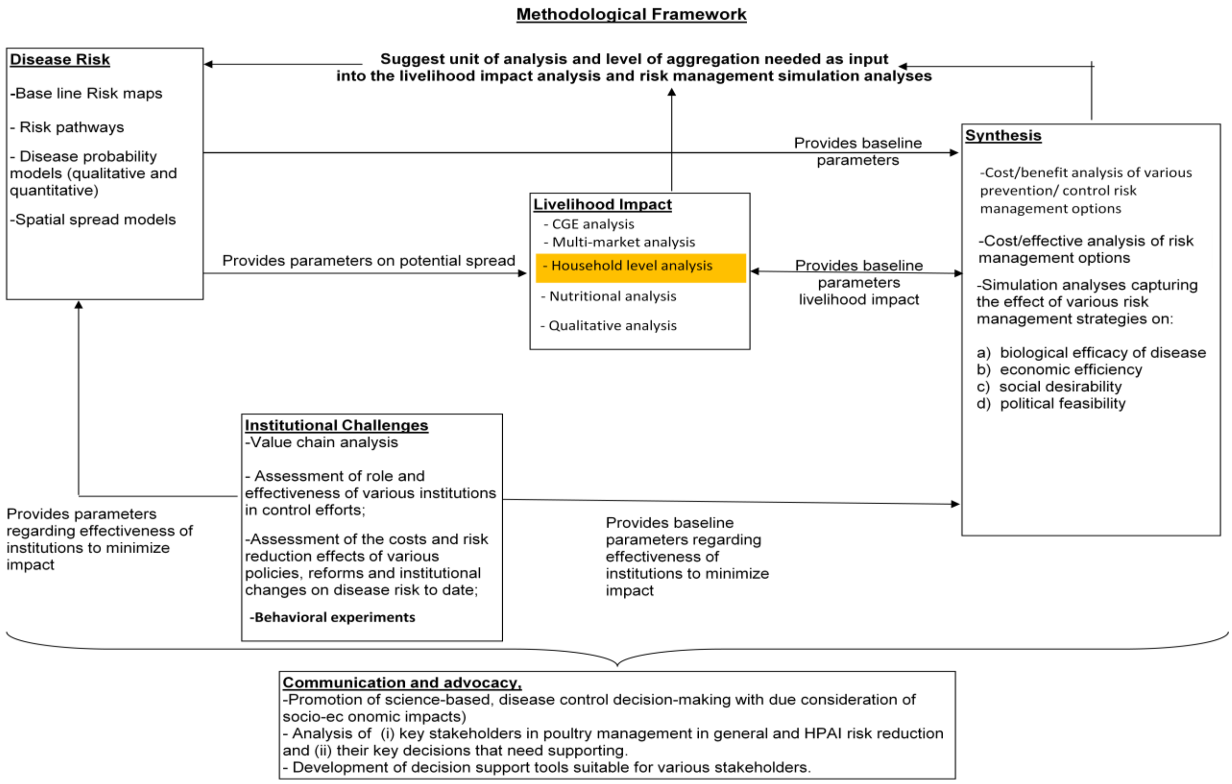
Preface

Since its re-emergence, HPAI H5N1 has attracted considerable public and media attention because the viruses involved have been shown to be capable of producing fatal disease in humans. While there is fear that the virus may mutate into a strain capable of sustained human-to-human transmission, the greatest impact to date has been on the highly diverse poultry industries in affected countries. In response to this, HPAI control measures have so far focused on implementing prevention and eradication measures in poultry populations, with more than 175 million birds culled in Southeast Asia alone.

Until now, significantly less emphasis has been placed on assessing the efficacy of risk reduction measures, including their effects on the livelihoods of smallholder farmers and their families. In order to improve local and global capacity for evidence-based decision making on the control of HPAI (and other diseases with epidemic potential), which inevitably has major social and economic impacts, the UK Department for International Development (DFID) has agreed to fund a collaborative, multidisciplinary HPAI research project for Southeast Asia and Africa.

The specific purpose of the project is to aid decision makers in developing evidence-based, pro-poor HPAI control measures at national and international levels. These control measures should not only be cost-effective and efficient in reducing disease risk, but also protect and enhance livelihoods, particularly those of smallholder producers in developing countries, who are and will remain the majority of livestock producers in these countries for some time to come.

To facilitate the development of evidence based pro-poor HPAI control measures the project is designed so that there are five work streams: disease risk, livelihood impact, institutional mechanisms, risk communication, and synthesis analysis. Project teams are allocating and collecting various types of data from study countries and employing novel methodologies from several disciplines within each of these work streams. So that efforts aren't duplicated and the outputs of one type of analysis feeds into another the methodologies in each work stream will be applied in a cohesive framework to gain complementarities between them based on uniformity of baselines and assumptions so that policy makers can have consistent policy recommendations. The figure below is the methodological framework used to depict how work stream outputs fit together. This brief discusses the methodologies to be used when conducting a simple livelihoods impacts approach highlighted in the methodological framework below.



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Disclaimer

The views expressed in this report are those of the author(s) and are not necessarily endorsed by or representative of IFPRI, or of the cosponsoring or supporting organizations. This report is intended for discussion. It has not yet undergone editing.

More information

For more information about the project please refer to www.hpai-research.net.

1. Introduction

One of the aims of the DFID funded Pro-Poor Highly Pathogenic Avian Influenza (HPAI) Risk Reduction Strategies Project is to understand the impacts of the HPAI outbreaks on poultry producers' livelihoods. As explained in greater detailed in Oparinde and Birol (2008), there are several potential mechanisms through which HPAI outbreaks might have impacts on various livelihoods indicators, including income from poultry sales and food and nutrition security, as well as on the value of poultry assets, i.e., household wealth from poultry. These mechanisms include the loss of poultry and/or reduced poultry productivity; reductions in the demand for and hence market prices of poultry, resulting in reduced poultry sales income; reductions in consumption of micronutrient rich poultry meat and eggs and hence increase in malnutrition levels; impacts on food security due to reduction in poultry income, and the overall loss in the value of household poultry assets, i.e., wealth, to name a few. Evidence based information on the extent of these impacts on livelihoods and the optimal mechanisms for their minimisation are currently limited.

The aim of this paper is to present a simple economic model which can be applied to available secondary data (e.g., data from Living Standards Measurement Study (LSMS) surveys of the project countries) in order to investigate the impact of HPAI outbreaks on two welfare indicators of poultry producers. These indicators are revenue from poultry sales, as a measure of household livelihoods, and poultry asset value, as a measure of wealth from livestock (i.e., poultry) and/or potential future revenue. In this simple framework, the impact of HPAI on poultry producers' revenue is assumed to stem from two causes: (i) changes in the price of poultry due to the loss of poultry as a result of HPAI, as well as due to other supply side and demand side shocks, and (ii) losses in poultry stock due to HPAI outbreaks both as a result of poultry death due to infection and loss in poultry due to government control policies, e.g., culling.

To this end, a simple theoretical model of poultry farmer and poultry market is developed to estimate the impact of HPAI outbreaks on market prices and poultry farmers' revenue and wealth. This framework highlights the impacts of pre-HPAI price elasticities of demand and supply and stock elasticity of supply, as well as HPAI induced demand and supply shocks on the market price of poultry. Various possible sources, from which the estimates of the magnitude and directions of demand and supply side shocks can be obtained, are introduced. In addition, methodologies for the estimation of price elasticities of demand and supply are presented. These include the use of different specifications of the Almost Ideal Demand Systems (AIDS) model for the demand estimation and the normalised quadratic profit function estimation, in addition to more simple linear estimations using two-stage least squares instrumental variables approaches. A simple demonstration of the model is presented for Indonesia by using demand and supply elasticities estimated by previous studies, as well as demand and supply shocks reported in the other case study countries of this Project. Finally, data required to apply this methodological framework and secondary data sources that can be used to estimate the parameters of the model are discussed.

2. A simple model of poultry market and poultry farmer

2.1 Poultry demand in the economy

The demand for poultry in the economy is depicted by the following formula:

$$D = D(p, 1, d; X) \quad (1)$$

where the demand for poultry, *D*, is a function of the price of poultry, *p;* price of all other consumption goods, which is implicitly taken as the *numéraire,* 1; *d* which represents the demand side shock, which captures households' reactions to the HPAI outbreaks, and *X*, other factors such as household characteristics. The demand function can be presented as a Cobb-Douglas function:

$$D = Ap^{-\alpha}d \quad (2)$$

where α is the price elasticity of demand. Equation (2) implies that if there are no HPAI outbreaks, then *d=1* and demand for poultry is a function of its price. If, however, there is a risk of HPAI outbreaks, then it is assumed that *d<1*. In this case the magnitude of *d* depends on several factors, such as households' perceptions of risk; media coverage (both in content and its efficacy in reaching households); other formal and informal communications networks in the country; governments' efforts to control media and to communicate the accurate messages regarding the extent of risk, as well as governments' credibility. Taking the natural logarithm of (2):

$$\ln D = \ln A - \alpha \ln p + \ln d \quad (3)$$

In the case of no HPAI outbreaks, $\ln d$ is 0 and the demand for poultry is a function of its price.

2.2 Poultry supply in the economy

The supply of poultry in the economy is depicted by the following formula:

$$Q = Q(p, C, s; Z) \quad (4)$$

where the quantity of poultry in the market, *Q*, is a function of the price of poultry, *p* and the stock of poultry in the economy, *C*, and *s* is the supply side shock which captures poultry producers' responses to HPAI outbreaks, and *Z* is the poultry producers' characteristics. The supply function can be presented as the following Cobb-Douglas function:

$$Q = Bp^{a}C^{b}s \quad (5)$$

where *a* is the price elasticity of supply and *b* is the stock elasticity of supply. *b* is assumed to be closer to 1 for those countries which have commercialised poultry sectors, and less than 1 for those dominated for backyard poultry sectors. It is assumed that if there are no HPAI outbreaks then *s=1*. In the case of HPAI outbreaks, the magnitude of *s* depends on various factors such as farmers' knowledge and attitudes towards HPAI, their biosecurity practices, proximity to markets and efficiency of surveillance to name a few. For example *s* might be *s>1* for those farmers who are located near markets and would like to sell all their poultry as soon as possible in the case of an HPAI outbreak, whereas it might be *s<1* for those who have high biosecurity and might want to sell after the outbreak and associated demand shocks have abated. Taking the natural logarithm of (5) poultry supply function can be expressed as:

$$\ln Q = \ln B + a \ln p + b \ln C + \ln s \tag{6}$$

In the case of no HPAI outbreaks, $\ln s$ is 0 and *b=1* and the market supply of poultry is a function of its price and quantity of poultry available.

2.3 Equilibrium in the poultry market

When the market is in equilibrium, the quantity demanded (equation 3) and supplied (equation 6) of poultry are equal:

$$\ln A - \alpha \ln p + \ln d = \ln B + a \ln p + b \ln C + \ln s \tag{7}$$

The impact of HPAI outbreaks on the poultry stock and hence on the market prices of poultry can be estimated by rearranging (7) and taking the derivative of *p* with respect to *C*.

$$\frac{d \ln p}{d \ln C} = -\frac{b}{(a+\propto)} + \frac{\partial \ln d}{\partial \ln C} + \frac{\partial \ln s}{\partial \ln C} \tag{8}$$

The first term on the right hand side depicts the impact of change in stock of poultry (due to death from HPAI infection and/or culling) on the price through its impact on stock elasticity of output, price elasticity of demand and price elasticity of supply. The second and third terms capture the impact of a change in poultry stock due to HPAI on demand shock and supply shock, respectively.

2.4 Impact on poultry farmers' revenue and wealth

The poultry farmer *i* is expected to have the revenue function of the form:

$$R_i = p{c_i}^{b_i} s_i \tag{9}$$

where revenue from poultry production is a function of market price of poultry, *p*; poultry stock of the farmer (i.e., number of poultry the farmer has, *c*), stock elasticity of supply which depends on the capacity of the poultry farm. For commercial/market oriented farmers *b* is assumed to be closer to 1, for semi-commercial farmers around 0.5, and for village poultry producers with a few birds closer to 0. Supply shock is assumed to be *s=1* in the case of no outbreaks and otherwise less than or greater than 1, depending on various characteristics of the farmer, as explained above, as well as on their market orientation.

The wealth of the poultry farmer, on the other hand, is given by the product of the number of poultry the farmer owns and the current value (market price) of poultry.

$$W_i = pc_i \tag{10}$$

3. Identification of model parameters

3.1 Demand and supply shocks of HPAI outbreaks and scares

In order to be able to calculate the HPAI outbreak induced revenue and wealth losses suffered by poultry producers, parameters that need to be estimated are $\propto$, *a, b, d* and *s*. To be able to estimate *d* and *s*, i.e., the magnitude and direction of demand and supply shocks, time series data are required on quantities of poultry demanded and supplied and the market prices, spanning over the periods before, during and after the HPAI outbreaks. Such data would enable measurement of the exact magnitude (and direction in the case of supply shocks) of the demand and supply shocks caused by the outbreaks. Unfortunately no such detailed country level time series data are readily available for the periods before and after the shocks, as reported in the background papers of study countries that have had HPAI outbreaks (Indonesia, Ghana and Nigeria) and scares (Ethiopia and Kenya). A review of the background papers and associated literature, however, reveals certain pointers regarding the magnitudes of demand and supply shocks suffered from HPAI outbreaks and scares.

In Indonesia several HPAI outbreaks have occurred since 2004 and the disease is currently considered as endemic. Regarding supply shocks caused by HPAI, an ongoing study by ILRI found that poultry producers are selling infected poultry at the markets at much reduced prices, revealing producers' willingness to sell off their stock as quickly as possible (ILRI, 2008, cited in Sumiarto et al., 2008). Moreover, in terms of demand shocks, Sumiarto et al. (2008), identify declining demand of poultry products as one of the most worrying impacts of HPAI outbreaks in Indonesia.

Even though the impact of the HPAI outbreaks on poultry meat consumption was only temporary and lasted approximately two months, the demand for high quality poultry produce has increased significantly after the outbreak. This demand, however could only be met by the by large-scale poultry producers, rendering small-scale poultry farmers to bear the costs of the outbreaks. The most significant negative impact of the HPAI outbreak to the national economy is the profitability of small poultry farmers. Sumiarto et al (2008) report that depending on the type of contract they had, the profitability of the smallholder poultry producers was reduced by 10.7% to 35.4% since the HPAI outbreaks. A study by Nugroho (2004) cited by Bogor Agricultural University (2007) also suggests that during the five cycles of production after the HPAI outbreak, small poultry farmers were able to make profits only in the first cycle, and experienced losses in the last four of the production cycles.

Anecdotal evidence from Ghana discloses that during the 2006 outbreaks in the neighboring countries, the magnitudes of supply and demand shocks were huge. In terms of supply shocks, poultry producers could not sell their produce and due to the increasing costs of keeping poultry (e.g., feeding and maintaining costs) they had to dispose of their produce as quickly as possible and hence they sold at extremely low prices. For example a crate of eggs was sold at 63.3% of its normal price (Aning et al., 2008). In terms of demand shocks, Ministry of Food and Agriculture of Ghana reported that "the scare of the bird flu alone led to a drastic reduction in the demand for poultry and poultry products." It was recorded by the Ghana National Association of Poultry Farmers that poultry consumers reduced their demand by 40% during these HPAI scares (GNAPF, 2006).

There have been three actual outbreaks of HPAI in Ghana in 2007 (Aning et al., 2008). There is no published information available on the demand and supply shocks and changes in prices after the outbreaks. There is, however, anecdotal information on the numbers of farmers who have gone bankrupt due to the loss of markets as a result of the ban on poultry and the reductions in the demand for poultry products, during and sometime after the outbreaks. For example, according to the Poultry Farmers' Association, the total number of their broiler producing members was reduced by 95%, whereas their broiler chickens was reduced by 83%. The number of their egg producing members also fell, though at a lower rate of 30%. At the country level, however, the total number of egg producers plummeted by 66.7%. These figures provide some indicators of the supply and demand shocks suffered by poultry farmers in Ghana (Aning et al., 2008).

In Nigeria, there have been several outbreaks of HPAI since February 2006, the most recent one occurred in July 2008 (Obi et al., 2008). A study conducted by the UNDP in 2006 right after the initial outbreaks revealed that the official confirmation of HPAI in Nigeria caused initial panic, resulting in the total boycott of poultry and poultry products. Consequently, within two weeks, egg and chicken sales declined by 80.5%, due to demand shock, and up to four months after, prices had not recovered up to 50% pre-HPAI levels. The study found that although the highest bird mortality rates occurred in commercial farms, overall rural village poultry and backyard and medium scale farmers were most severely affected by the HPAI outbreaks, since they lack necessary assets for recovery and often do not qualify for compensation (especially village extensive poultry producing households). Affected backyard producers suffered up to a 100% income loss, while non-affected producers also witnessed income losses as high as 68.2% (UNDP, 2006; Obi et al., 2008).

State level studies conducted in Nigeria found that HPAI resulted in a 57% drop in the chicken prices in the Kwara state (Obayelu, 2007). The household level demand shock was as high as 80%, and supply shock resulted in 75% of poultry farmers to stop ordering of new supplies of birds and to opt out of poultry farming altogether. According to Obayelu (2007) small scale commercial producers and backyard poultry farmers suffered the most income losses as a result of HPAI. A more recent study conducted by UNICEF and AED in Kano and Lagos states found that HPAI shocks resulted in substantial losses in employment in the poultry sector, as well as sharp decreases in prices of poultry. In Kano, the price of chicken in the markets dropped by as much as 90%, while in Lagos the price fell by 81.25% (UNICEF/AED, 2008).

There have not been any actual HPAI outbreaks in Ethiopia, however there was a HPAI scare in 2006, due to a false alarm in a state run poultry multiplication centre. This scare caused a massive demand shock, which subsequently led to sharp falls in poultry prices (Alemu et al., 2008). Bush (2006) reports that this scare led to a demand shock, especially in urban areas, which decreased poultry demand by 25-30 %. As a result of reduction in urban demand and the consequent over-supply of local markets, the prices of chicken sold at the local markets dropped by 50-60%. The scare, however did not affect egg supply, demand and price (Bush, 2006).

Finally, in Kenya, similarly to Ethiopia, there have not been any actual outbreaks of HPAI, however there was a major HPAI scare that took place September 2005 through March 2006 (Omiti and Okuthe, 2008). The scare was initiated by misguided reports by the media, compounded by HPAI actual outbreaks in neighbouring Sudan. Kimani et al. (2006) assessed the demand and supply shocks caused by this scare to be highly significant. According to this study, as a result of this scare, 25% of farmers prematurely culled their birds. The prices of poultry and poultry products were also affected by the HPAI scare. The price of broiler chicken fell by 15% per kg, whereas the prices of eggs fell by 15.3% per tray. The demand and supply shocks caused by the scare also reduced the prices of indigenous eggs and chickens, by 7.2% per tray and 26.5% per kg, respectively (Kimani et al., 2006). Moreover, during the multi-stakeholder meetings of this Project, Kenyan stakeholders have reported that a demand shock of 60% was observed following these scares.

The impacts of HPAI outbreaks and scares on demand and supply shocks as well as prices are summarised in Table 1. In summary, the demand shock caused severe decreases in demand ranging from 25% to 80%, depending on various factor (whether it was an outbreak or scare, the role of the media etc.). Whereas supply shocks generally resulted in overflowing of local markets with poultry produce, except in Kenya when the scare induced farmers to cull their own flocks. Overall these shocks resulted in reductions in egg prices, ranging from 7% to 63%, and in poultry prices ranging from 15% to as high as 90%.

Table 1. Impacts of HPAI outbreaks and scares on demand, supply, prices and producers

HPAI scare/outbreak impact on	**Indonesia**	**Ghana**	**Nigeria**	**Ethiopia**	**Kenya**
Demand shock	Sharp decline within two months of outbreaks; Increase in demand for high quality poultry.	40% reduction in poultry demand.	First two weeks after the outbreak 80.5% reduction in demand; 80% reduction in demand in Kwara state.	Especially in urban areas 25-30% reduction in demand for poultry meat.	60% reduction in demand.
Supply shock	Infected poultry sold hastily at markets at lower prices.	Poultry sold hastily at markets at lower prices.		Over-supply in local markets.	25% of farmers culled their own stocks.
Producers/poultry sector	Small scale producers cannot supply high quality produce and lost income by 10.7-35.4%.	Poultry Farmer Association members reduced by 95% for broiler and 30% for egg producers; Total egg producers in the country fell by 66.7%.	Small scale, backyard and rural poultry producers most affected: Farmers with infected flocks suffered income loss up to 100% and non-affected ones lost 68.2% of income; In Kwara state 75% of farmers left poultry sector.		
Price of eggs		63.3% reduction.		No affect.	15.3% for commercial eggs and 7.2% reduction for indigenous eggs.
Price of chicken			57% reduction in Kwara state; 90% reduction in Kano state; 81.25% reduction in Lagos state.	50-60% reduction.	15% reduction for commercial chicken and 26.% reduction for indigenous chicken.

3.2 Econometric models for the estimation of elasticities

In this section we will focus on the estimation of α, price elasticity of demand, *a,* price elasticity of supply and *b* stock elasticity of supply.

Demand parameters are usually estimated by applying regression analysis techniques to data on quantities demanded, price and income or share of expenditure on specific commodities and total expenditure. There are several different demand models than can be used to estimate the price elasticity of demand, the choice of which generally depends on the availability of data. The most popular demand models are the Linear Expenditure Systems (LES), Almost Ideal Demand System and their variants (Ravi and Roy, 2006). LES models are generally used to estimate the demand for comprehensives categories of goods such as clothing, housing, food etc., and hence would not be appropriate in this context when the demand elasticity of interest is one specific good (chicken or eggs) (Stone, 1954). In order to ensure that the elasticities estimated are robust, various models e.g., simple linear models as well as variants of the AIDS models can be estimated and the best-fitting one could be selected based on the appropriate tests.

First, a simple regression analysis comprising of a single equation model can be used to explain the demand parameters for a single commodity (e.g., chicken).

$$q_d = \propto_0 + \propto_1' p + \propto_2' X + \epsilon \quad (11)$$

Which is the demand curve relating q_d, the quantity demanded, to price *p* and *X*, other possible household level covariates (e.g., total household income, regional dummies, household demographic and gender composition, to name a few). Generally the logs of all variables are taken, since the aim is to estimate a constant elasticity of demand model, which would allow for interpretation of the coefficients as elasticities. This single equation model can be estimated with the Ordinary Least Squares (OLS) method, however, endogeneity may arise since price is jointly determined with quantity. This can be tackled with the use of the instrumental variables (IV) two stage least squares (2SLS) method, if appropriate instruments can be identified.

Second, systems models (such as the Linear Approximate version of the Almost Ideal Demand System (LA/AIDS)) can be used to estimate the demand of a group of similar commodities (e.g., all meat types) simultaneously (Deaton and Muelbauer, 1980). AIDS models use budget shares or expenditure on goods, rather than the household income when estimating the demand system. Specifically a simple depiction of the model estimated is

$$y_p = \alpha_0 \ + \beta lnY + X \quad (12)$$

Where y_p is the share of budget spent on the specific commodity (e.g., chicken or eggs), *Y* is the total expenditure, and X is the household level covariates as explained above. LA/AIDS models have been used in several countries to estimate the demand for various foodstuff, among other commodities. For example Alfonso and Peterson (2006) used this model to estimate demand elasticities for 12 food categories in Paraguay. They found that demand elasticity for chicken to be -1.0746 for chicken and 0.0294 for eggs. Similarly, Hutasuhut et al. (2001) use the LA/AIDS model to estimate Indonesian consumers' demand for different meat products and find the price elasticity of chicken to be -1.09.

In addition to the LA/AIDS model, other versions of the AIDS models include Quadratic AIDS (QUAIDS) and Finite Mixture AIDS models. QUAIDS model takes into account the fact that some consumer preferences might be quadratic in nature (Banks et al., 1997). A recent application of the QUAIDS in Malawi estimated the price elasticities for various foodstuff and found the price elasticity of white meat to be -0.978 and for eggs -1.213 (Ecker and Qaim, 2008). Finite Mixture AIDS models, on the other hand, controls for heterogeneity of preferences within the sample by allocating households to clusters, each one of which depict homogenous preferences. Bertail and Caillavet (2008) have recently applied this model to investigate the heterogeneity in French consumers' fruit and vegetable consumption patterns.

Supply parameters are also estimated by applying regression analysis techniques. Similarly, to the simple estimation of demand, a simple model can be used to estimate:

$$q_s = a_0 + a_1'p + b'C + \varepsilon \qquad (13)$$

Which is the supply curve relating q_s, the quantity supplied, to price *p* and number of chicken in the country (the chicken stock) *C*. Similarly to the demand regression the logs of all variables are taken in order to estimate the elasticities (i.e., price elasticity of supply and stock elasticity of supply). Potential endogeneity problems that may arise as a result of the joint determination of price and quantity, may be tackled by the use of the IV 2SLS, where the appropriate instruments for price supplied could be prices of inputs.

In addition to this simple specification, similarly to Fabiosa et al. (2004) a normalized quadratic function will be used to estimate the output supply and input demand of poultry producers. Output supply as well as input demand elasticities are sensitive to the choice of functional forms (i.e., whether translog, generalized Leontief, and normalized quadratic) (Shumway and Lim, 1993), and normalized quadratic functions are generally preferred due to their parsimony and easier estimation of their linear specification (Fabiosa et al., 2004). In this model specification the profit function is specified as a normalized quadratic profit function:

$$\hat{\pi} = b_0 + \sum_i b_i \frac{w_i}{p} + \frac{1}{2}\sum_i \sum_j b_{ij} \frac{w_i}{p}\frac{w_j}{p} \qquad (14)$$

Where p is the price of poultry (output), and where w_i is the price of stock of poultry and w_j is the price of other inputs, such as feed. The derived equations for estimating input demand and output supply are:

$$x_i = -\left(b_i + \sum_i b_{ij} \frac{w_i}{p}\right) + \varepsilon_i \qquad (15)$$

$$y = b_0 - \frac{1}{2}\sum_i \sum_j b_{ij} \frac{w_i}{p}\frac{w_j}{p} + \mu_i \qquad (16)$$

Where the error terms are identically and independently distributed. This system of equations (15) and (16) can be estimated by using seemingly unrelated regression (SUR) techniques.

4. A simple demonstration with some available information

This section simulates the simple model introduced in section 2 by using estimated price elasticities of demand and supply for the Indonesian poultry sector. Fabiosa et al. (2004) used registered enterprise data from 2000 to estimate the price elasticity of poultry supply to be 0.285, whereas Hutasuhut et al. (2001) used 1990, 1993 and 1996 SUSENAS data and estimated the price elasticity of poultry demand to be -1.09. Overall *b* for the country is assumed to be close to 1 (i.e., 0.9) since Indonesia has a large poultry industry comprising both large and medium scale commercial farms as well as small scale, backyard producers most of whom actively participate in wet markets (Sumiarto et al., 2008).

In the case of no outbreaks (before 2004), equation 8 above reduces to the first term which is (0.9/(-1.09+0.285) =-1.12), which translates to 1% reduction in poultry stock, *C*, resulting in 1.12% increase in poultry prices, *p*. Changes in poultry income of backyard, medium and large scale poultry producers are calculated as follows:

- In the case of a backyard poultry producer that keeps 50 chickens, about 30 of which he sells at the market (i.e., *b*=0.87), for an increase in price from 1 to 1.0112 and a decrease in stock of chicken by 1% from 50 to 49, his revenue would fall by ($1.0112 \times 49^{0.87} - 1 \times 50^{0.87}$) = -0.2 due to a 1% reduction of overall stock of poultry (including his own). The wealth of the poultry producer (i.e., the value of his poultry assets) decreases by (1.0112x49 - 1x50) = -0.45

- In the case of a medium scale poultry producer that produces 1000 chickens and sells all but saves around 10 for household consumption (i.e., *b*=0.9986), for an increase in price from 1 to 1.0112 and a decrease in stock of chicken by 1% from 1000 to 990, his revenue would increase by ($1.0112 \times 990^{0.9986} - 1 \times 1000^{0.9986}$) =1.12. The value of the medium scale producer's assets increase by (1.0112x990 - 1x1000) = 1.09.

- Finally in the case of a large scale fully commercialised poultry producer that keeps 10000 chickens and sells all (i.e., *b*=1), for an increase in price from 1 to 1.0112 and a decrease in stock of chicken by 1% from 10000 to 9900, his revenue, which in this case is equal to his total wealth would, increase by (1.0112x9900 - 1x10000) =10.9.

Therefore overall small scale producers/backyard poultry keepers would lose, however, medium and large scale producers would gain from a 1% reduction in supply and the consequent 1.12% increase in the price of poultry.

As discussed above, unfortunately information on the magnitudes of supply and demand shocks are not available for Indonesia. Evidence from other Project countries suggests demand shocks ranging from 25-30% in Ethiopia to as high as 80% in Nigeria, as reported in Table 1. For the purpose of this demonstration a moderate demand shock of 40% is assumed. Similarly, information on the exact magnitude of the supply shocks are also limited for all project countries, though there are reports of increased supply in the markets in Indonesia following the outbreaks. Therefore the overall supply shock for the poultry sector is assumed to increase with the outbreaks by around 20% on average, if all producers (especially many smaller scale producers who do not currently sell all their produce) try to maximise the number of birds they take to the market in order to sell them as soon as possible.

Equation 8 above is used to estimate the impacts of HPAI outbreak which causes a 10% loss in the overall poultry stock of the country, following Vanzetti (2007). The direct impact of this stock loss is 11.2% increase in the price due to reduction in supply; 40% decrease in the price due to demand shock and a 20% decrease in price due to supply shock that leads to more poultry to enter the market. This results in the overall decrease in the poultry price by 48.8%. Revenue and wealth losses suffered by the three different poultry producers become:

- In the case of a backyard poultry producer that keeps 50 chickens and generally sells 30 (i.e., *b*=0.87) at the wet market, a 10% reduction in his stock would result in the loss of 5 birds. Assuming constant *s,* for a decrease in price from 1 to 0.512 (for 48.8% decrease in price) his revenue would decrease by ($0.512x45^{0.87}$ - $1x50^{0.87}$) = -16.1. If the farmer increased his sales by 40%, his losses would only be -10.4. Even if the farmers' flock was not affected by HPAI, and with b=0.87 and *s* constant, he would still be incurring revenue losses as high as 14.6 due to the decrease in overall poultry prices. The overall poultry wealth of the farmer would decrease by 27.

- In the case of a medium scale poultry producer that produces 1000 chickens with b=0.9986, a 10% reduction in his stock would result in the loss of 100 birds. Assuming constant *s,* for a decrease in price from 1 to 0.512 his revenue would decrease by ($0.512x900^{0.9986}$ - $1x1000^{0.9986}$) = -534. Even if the farmer increases his sales by 1%, he would still be incurring revenue losses as high as 529.4 due to decrease in price and in number of birds. The overall wealth of this medium scale producer would be reduced by 539.2.

- Finally in the case of a large scale fully commercialised poultry producer that keeps 10000 chickens and sells all (i.e., *b*=1), a loss of 10% of his flock would result in 9000 birds. Assuming constant *s,* for a decrease in price from 1 to 0.512 his revenue as well as his wealth would decrease by (0.512x9000 - 1x10000) = -5392.

These changes in different size producers' revenues and wealth, as well as changes in case of 80% demand shocks are summarised in Table 2 below. Even though HPAI outbreak and associated shocks cause the largest revenue and wealth losses for the larger scale producers, it should also be taken into consideration that small scale backyard producers as a group constitute a larger proportion of the poultry producers in Indonesia and hence aggregated losses are expected to be much larger.

Table 2. Simulated changes in income and wealth dues to HPAI induced supply and demand shocks and price changes

	Backyard producer C=50, b=0.87	**Medium scale producer C=1000, b=0.9986**	**Large scale producer C=10000, b=1**
1% reduction in C and 1.12% reduction in price			
Change in revenue	-0.2	+1.12	+10.9
Change in wealth	-0.45	+1.09	+10.9
10% reduction in C, 40% demand shock, overall 20% supply shock and 48.8% reduction in price			
Change in revenue	-10.4 if *s* constant -16.1 if *s* 40% increase	-534 if s constant -529.4 if *s* 1% increase	-5392
Change in wealth	-27	-539.2	-5392

5. Data requirements, availability and concluding remarks

There are several secondary level data sources available for the study countries. For a detailed review of these please see Roy and Tiongco (2008). Price elasticity of demand can be estimated by the use of the national level household survey data from each one of the study countries. The following data sets can be used:

1. Ethiopia: Ethiopia Household Income, Consumption and Expenditure Survey, 2004,
2. Ghana: Ghana Living Standards Survey (GLSS) 2005,
3. Indonesia: Indonesia Family Life Survey (IFLS) 2000,
4. Kenya: Kenya Integrated Household Budget Survey (KIHBS) 2004, and
5. Nigeria: Nigeria Living Standards Survey (NLSS) 2004.

Each one of these data sets have information on the numbers of poultry owned and bought by each household, as well as the total value of poultry and the current prices of poultry. In addition, these data sets contain information on various other household level indicators, such as the demographic characteristics of the households, and the total household expenditure, also disaggregated according to expenditure type, which can be used to estimate the share of budget that is spent on poultry and other goods.

For estimation of the supply elasticity, producer level data would have been ideal, however currently we have not got access to such data in any of the study countries. The secondary data sources mentioned above do contain some information on the number of poultry owned, their current prices, number of poultry sold, and the total value of poultry sales, as well as total household expenditure on livestock inputs which can be used for the estimation of the supply function. Moreover, these data sets also contain information on the households' asset base (i.e., various assets owned by the household including human capital (education level), labour and physical capital) and households' various livelihood strategies (diversification of sources of income). These data can be used to estimate the role of poultry revenue in the total household income and the impacts of HPAI shocks and scares on the overall household income.

Accurate information on the extent of the demand and supply shocks may not be easily accessible. Some indication of the shocks could be extracted from the Knowledge, Attitudes and Practice (KAP) Surveys conducted by the UNICEF in all of the study countries. KAP surveys of poultry producers and poultry marketers evaluated poultry handling behavior, whereas KAP studies with the general public investigated public's perceptions of HPAI risk and poultry consumption practices. Some information on the demand and supply shocks could also be obtained through interviews with the poultry farmers' associations, fowl sellers' association and similar organizations within each country. Since it is unlikely that the magnitude of these shocks will be known with certainty, sensitivity analyses will be carried out, and HPAI impacts on poultry producers' revenue and wealth will be calculated for different sizes of demand and supply shocks.

A final piece of information needed for estimation of the HPAI impact on producers' revenues and wealth is the risk of poultry loss, i.e., in case of an outbreak what percentage of their poultry (if any) are producers of different sizes located in different regions of each country are likely to lose. For the simple demonstration presented here, for the analyses conducted in Diao (2008) and in Birol and

Asare-Marfo (2008) a 10% uniform poultry loss was adopted, as suggested by Vanzetti (2007). It is however expected that the disease risk maps that will be developed for each study country will enable estimation of the impacts of more accurate HPAI risks for different size producers located in different regions of each country.

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