Issues in estimating economic effects of a disease outbreak in poultry
The case of Newcastle disease

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Three issues in estimating producer losses from an outbreak of Newcastle disease in the poultry industry are discussed in this paper. First, annual producer losses from the short to intermediate run are estimated. Second, producer losses are estimated taking account of the substitution effects on other meat markets. Third, an annual aggregate model is used to estimate producer losses occurring during a part of a year in a part of the industry. The elasticity version of EMABA was used in estimating producer losses.
Introduction

There are three simplifying assumptions that are frequently used when estimating the costs of exogenous shocks to agricultural commodity supplies caused by factors such as a disease outbreak. First, it is usually assumed that the disease becomes endemic across the whole country. Second, a once off and immediate supply adjustment is assumed. Third, by taking a partial equilibrium approach the effects of the shock on other commodities are assumed to be negligible. This paper outlines an approach used to estimate the economic cost to the Australian chicken meat industry of a part country spread of Newcastle disease which is eradicated after the initial outbreak (non-endemic), taking into account a lagged adjustment in supply and the substitution effects on other meat markets.

In this paper it is assumed that the outbreak of Newcastle disease would be confined to one chicken meat producing region with the total production effect of the outbreak and consequent eradication strategy extending over about 6 months. In practice, it may take a number of years for the effects of the initial shock to wear off, even in intensive livestock enterprises such as poultry. Estimates of the time path of producer losses from a disease outbreak should include account of the costs of adjustment (including the costs of supply shifting investment).

The impacts of change in one industry on industries producing competing products may be significant. For the example considered in this paper, chicken meat is a close substitute in consumption to other meats. Therefore, any change in the price of chicken meat influences the demand for, and thus the prices of, other meats. Changes in the prices of other meats feed back to the demand for chicken meat. It is important that losses to producers from such interdependent effects between meat markets are accounted for.

Basis of surplus measures

For the purpose in this paper it is accepted that path independent measures of consumer surplus can be provided in a multicommodity framework (Just, Hueth and Schmitz 1982). The producer side measure of gain or loss needs some further consideration. Supply side

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1 Newcastle disease is caused by a virus called avian paramyxovirus and occurs in domestic fowls, turkeys, pheasants, pigeons, quail, guinea fowl and numerous species of wild and captive birds. The several strains of the virus are generally classified into three categories as velogenic (highly virulent), mesogenic (moderately virulent) and avirulent, depending on the speed at which they cause mortality. The velogenic and mesogenic strains do not occur in Australia and are collectively known as exotic Newcastle disease. Initial signs of disease may include depression, loss of appetite, rapid decline in egg production, diarrhoea, severe coughing and gaping. Nervous signs such as head tremors and wing paralysis usually follow. The disease tends to appear suddenly and spreads rapidly, particularly within flocks confined in modern, high population density sheds. Mortality rates can reach 100 per cent in young and adult bird populations within periods of 24 to 72 hours (Geering and Forman 1987).
measures of ‘producer surplus’ are still extensively used in the agricultural economics and trade literature but the validity and the clarity of meaning of the measures varies greatly from study to study.

Mishan (1968) points out that the idea that there will be producer rents is generally inconsistent with the assumptions underlying the competitive economic model. Even when there are clearly rents accruing to owners of some productive factors, the area between the estimated supply curve and the price line (producer surplus) may not be a useful measure of those rents. Mishan mentions two exceptions to this generalisation. First, if the upward slope in a long run industry supply curve reflects the long run fixity of supply of a single factor, a meaningful measure of producer gains (that is, gains to the owners of the fixed factor) can be derived from the product supply curve. Second, where a short run inelasticity of product supply is caused by capital fixity, the area between the price line and the supply curve is a measure of quasi-rent to the capital concerned. In both cases it is valid to take the area between the supply curve and the price line as a measure of factor rent, because the supply curve is a representation of industry marginal costs, excluding factor rent.

The idea that long run supply curves for agricultural products slope upwards exclusively because of the limited supply of agricultural land underlies the use of supply side surplus measures in the assessment of benefits from rural research (see Edwards and Freebairn 1981, 1984). The use of estimates of short term producer gains and losses is discussed further below.

Temporal aggregation of changes in producer gains or losses

Provided short to medium run supply curves can be validly interpreted as reflecting industry marginal costs, it would seem that they could be used to estimate producer gains and losses from exogenous events over the adjustment period. A time series of producer gains or losses could be calculated and these estimates could then be discounted and aggregated as part of a benefit–cost analysis. Changes in ‘producer surplus’ measures can be used for temporal aggregation only when each is derived from a supply curve for the relevant length of run. In other words, producer gains for year 1 are measured from a 1 year supply curve for the first year, a 2 year supply curve for the second year and so on (Just, Hueth and Schmitz 1982). Obviously, it also needs to be clear that it makes sense, given the structure of the particular industry, to suggest that there are rents to factors which are fixed over each particular length of run included in the analysis.
Variable length of run supply curves are important in agriculture to capture lags in the process of adjustment after a price change. Even though this feature has been adequately observed in modelling supply response in agriculture, it has been largely ignored in calculating changes in producer welfare. The main reason for this apparent inconsistency lies in differences between the objective in a supply response study, where the researcher is interested in achieving a high model predictive performance, and the objective in an applied welfare study, where the researcher is interested in the effects of an intervention or a policy change (Janssen 1993).

Dynamic elements such as lagged adjustments in economic variables are incorporated in supply models to improve predictive and forecasting performance. Even though such dynamic models are used to estimate the effect on endogenous variables of a policy change or an intervention, few researchers have gone further and used the results in welfare calculations because welfare calculation in a dynamic model is less straightforward than it is with a simple static model. An example in which dynamic estimates of welfare change are calculated in a model consistent fashion (Janssen 1993) is discussed later in this paper.

Sometimes long run supply elasticities are used along with quantities and price, estimated by solving distributed lag models, to calculate producer gains or losses. For example, McKelvie, Hamal and Reynolds (1993) used the Econometric Model of Australian Broadacre Agriculture (EMABA) to simulate the effects on quantity and price of beef and veal, sheep meat and wool of an invasion of screw worm fly. These quantities and prices are then used along with respective long run supply elasticities to calculate losses to producers. It is shown below that this approach leads to an underestimation of producer losses.

A perfectly competitive market for a commodity is illustrated in figure 1. The demand curve is given by $D$ and the initial short run supply curve is given by $S$. A new supply curve, $S_1$, reflects the impact of an exogenous cost increase, such as a disease outbreak. It is assumed that the supply curves represent industry marginal cost curves for the relevant period, so valid measures of producer losses can be derived.

The loss to producers from the disease outbreak ($LPS$), which causes a move from the original short run equilibrium ($P_0, Q_0$) to the new short run equilibrium ($P_1, Q_1$), is given by the area $ijaf$ minus the area $P_1bjP_0$ and this can be measured with equation 1.

\[
LPS = \frac{1}{2} [k - (P_1 - P_0)](Q_0 + Q_1)
\]
Figure 1: Effect of a contraction of supply

where \( k \) is the vertical shift measured in the same unit as price.

For small changes, the vertical shift, \( k \), can be approximated by dividing the horizontal shift, \( h \) (measured in same unit as quantity), by the slope of the supply curve as is given in the following expression:

\[
k = h \frac{P_{n0}}{\varepsilon_n Q_{n0}}
\]

where \( \varepsilon_n \) is the supply elasticity with \( n \) length of run.

Therefore, the more elastic the supply the smaller will be the estimated value of \( k \) (and therefore \( LPS \)) for a given supply change. The conclusion is that the use of a long run supply elasticity would lead to an underestimation of producer losses in all the years in the lead up to the long run. The underestimation is at its maximum in the short run and would become smaller toward the long run.
The approach taken by McKelvie, Hamal and Reynolds (1993) may be argued to yield a reasonable approximation because the use of EMABA to calculate changes in the beef and veal, lamb and pig meat industries is not as straightforward as it is for chicken meat in this paper. This is because the adaptive price expectation captured for these commodities in the model induces shifts in the short run supply curve. As shown by Just, Hsueth and Schmitz (1982) and later applied by Janssen (1993), the cost of investment made to shift the short run supply curve to its next position should be subtracted from the estimate of producer gains calculated with the new short run supply curve if the gains or losses to producers calculated with the two short run supply curves are to be aggregated. The cost of investment that shifts the short run supply curve can be estimated from the long run supply curve.

Simple supply equations, where supply is specified as a function of the current year's or past year’s price, are often employed in calculating gains or losses, thereby assuming immediate (or in the next year if only a lagged price is used) adjustment in supply to price change. Most applied welfare analyses have been made by considering movement from one long run equilibrium to another long run equilibrium and a static modelling framework is often chosen by analysts as dynamic features are less important in the long run. Some researchers have chosen a medium run supply curve to estimate changes in rents to producers for a period of time so that the estimates can be used for temporal aggregation (see, for example, Hinchy and Low 1990).

However, measuring changes against long or medium run supply curves and using them in benefit–cost analysis has two disadvantages. First, costs and benefits for the immediate years cannot be included in the benefit–cost analysis as no measure of short to medium term rents to producers is included. For example, Hinchy and Low estimated the loss of producer welfare due to fire blight outbreak in the apple and pear industry in 1990 (over a ten year period) assuming that it takes five years to reach a new equilibrium. Because of the medium to longer term nature of the information developed in such analysis it has less immediate relevance.

Second, this approach would be useful only in those extensive agricultural enterprises where there are long run rents to producers or the long run supply curve is upward sloping. It is argued that the long run supply of poultry products (and that of pig meats) is likely to be infinitely elastic as the intensive agricultural production techniques used in their production require little land, implying that there are no long run rents to producers (Anandajayasekeram, Rose and Holland 1993). Therefore, in intensive agricultural
enterprises, the only question of relevance is whether there are short to medium term gains or losses to existing producers that can be measured validly. The emphasis must, therefore, be on the process of adjustment to any exogenous changes.

There are studies where lagged supply adjustments have been incorporated in static models which are used for welfare calculations. Lemieux and Wohlgenant (1989) used a static elasticity model to calculate short, intermediate and long run producer and consumer gains from the use of growth hormones on pigs in the US. In that study, the authors estimated meat demand elasticities with a Rotterdam system of equations and variable length of run pig meat supply elasticities with a distributed lag supply equation. Mullen, Wohlgenant and Farris (1988) have also used a static elasticity model to calculate short, intermediate and long run gains in economic surplus from a lower beef processing cost in the US.

**Single market versus multimarket approach**

A single market partial equilibrium approach has been used in a number of studies on applied welfare analysis assuming that changes in one industry are not likely to have a major impact on other industries. For example, studies conducted to calculate benefits from demand raising research on Australian pig meat by Voon and Edwards (1992) and social cost of regulation on Australian pig industry by Wilcox (1989) used this assumption, thereby ignoring the substitution effects on the other meat markets.

Use of a multimarket approach allows the measurement of changes in equilibrium quantities and prices in a given market by simultaneously taking account of all equilibrium adjustments in other markets. If such an approach is adopted, social welfare effects of changes in the supply or demand in a given market are captured completely in that market (Just, Hueth and Schmitz 1982). Multimarket approaches have been used by Lemieux and Wohlgenant (1989), Voon (1992) and Mullen, Wohlgenant and Farris (1988) and Mullen, Alston and Wohlgenant (1989).

Voon (1992) compared the results obtained from a single market approach with that of a multimarket approach to estimating the benefits of demand raising research in the Australian pig industry. He found that a single market approach would underestimate the gain to pork producers and overestimate gains to pork consumers from demand raising research; however, the aggregate benefit to Australia was largely unchanged. The closer are the commodities as substitutes in consumption (the greater the cross-price elasticity) the larger are the differences between the single market and multimarket results. However,
as is noted above, it seems unlikely that rents to intensive pork producers are sustained over the long term. In the long term, gains are likely to be sustained only for consumers.

In the case of a contraction of supply (say due to an outbreak of disease), it is shown below that use of a single market approach may result in an overestimation of the loss to producers and an underestimation of the loss to consumers. A competitive market for chicken meat which has a close substitute in beef is illustrated in figure 2. The original market equilibrium is determined by the intersection of the chicken meat supply curve, \( S \), and the chicken meat demand curve for a given price of beef, \( D_{b0} \), at quantity \( Q_0 \) and price \( P_0 \). If supply contracts to \( S_1 \) the equilibrium price moves up to \( P_1 \) and quantity adjusts to \( Q_1 \).

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**Figure 2: Producer losses in single vs two-market equilibrium**

![Diagram showing producer losses in single vs two-market equilibrium](image)
Table 1: Welfare effects between single market and two-market equilibrium

<table>
<thead>
<tr>
<th>Change in welfare</th>
<th>Single market</th>
<th>Two-market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumers</td>
<td>(-a - d)</td>
<td>(-a - c - d - e)</td>
</tr>
<tr>
<td>Producers</td>
<td>(a - b)</td>
<td>(a + c - b)</td>
</tr>
<tr>
<td>Society</td>
<td>(-b - d)</td>
<td>(-b - d - e)</td>
</tr>
</tbody>
</table>

However, beef demand may increase in response to a higher chicken meat price, leading to an increase in beef price. Chicken meat demand at the new beef price is given by \(D_b_1\). The new two-market equilibrium is given by price \(P^*\) and quantity \(Q^*\). The original and the new two-market equilibrium positions trace out the general equilibrium demand curve for chicken meat, \(D^*\). To help simplify the geometric illustration, income compensated demand curves are assumed so that the welfare measures shown are unique and path independent. (Path dependency in welfare calculations is explained in Just, Hueth and Schmitz 1982.)

Table 1 shows that losses to consumers may be underestimated by \(c + e\) and losses to producers over estimated by \(c\) in a single market framework.

National level effect of a part country non-endemic disease

The analytical framework for estimating social benefit–cost of a supply shift occurring in a part of the industry is developed in Edwards and Freebairn (1982). Earlier studies on the economic impact of disease considered endemic disease situations. There are two important aspects of the worst case outbreak scenario developed for Newcastle disease in Hafi, Reynolds and Oliver (1994). First, the disease is assumed to spread rapidly in the Hunter Valley and outer Sydney areas of New South Wales, which have the highest concentration of chicken meat production in Australia. Second, the introduction of Newcastle disease is assumed to lead to a complete loss of production for about six months in all farms in the Hunter Valley and outer Sydney areas as a result of sudden death of birds and the slaughter and destocking components of an effective eradication strategy.

The affected region would cease to produce chicken meat and eggs for five to six months following the outbreak. Therefore, for estimating the national level impact of Newcastle disease, an analytical framework with quarterly or half yearly supply and demand curves for chicken meat should ideally be used. However, as the estimation of economic effects at the national level is to be conducted using an annual framework, it is important to see
how a production loss due to Newcastle disease occurring during a part of a year is translated in an annual supply curve. The effects of a complete lack of production in the affected region during a part of a year on that regions’ annual supply curve and on the aggregate annual supply curve are illustrated in figure 3.

The annual supply curve of the affected region in the absence of a Newcastle disease outbreak is $S_a$ (figure 3a) and that of rest of New South Wales and other states is given by $Sr$ (figure 3b). $S$, the horizontal summation of $S_a$ and $Sr$, is the aggregate annual supply curve. $D$ is the aggregate demand curve. Market equilibrium is reached at price $P_0$ and output $Q$.

With the Newcastle disease outbreak, production at $P_0$ is cut by $h$. It is assumed that the costs of supply of units up to $Q_a$ is unaffected by the outbreak. Marginal costs of additions to supply at prices above $P_0$ are also assumed to be unaffected by the disease outbreak. The regional supply curve given the outbreak is, therefore, $S_{a1}$ (or $aced$). The annual supply curve of the rest of New South Wales and the other states is unaffected. The new aggregate supply curve is $S_1$ (or $fijl$). The equilibrium price would increase to $P_1$, with aggregate quantity supplied $Q_1$.

**Length of run effects of a non endemic disease**

At an aggregate level, the losses to producers and consumers and the transfer from producers to consumers due to a Newcastle disease outbreak in the short to intermediate
run are explained below (figure 4). The aggregate supply curve with Newcastle disease outbreak is given by $S_1$ (as in figure 3c).

The loss to the producers in the affected region due to a contraction of supply is measured by the area $aij$. The loss to the consumers due to a reduction in consumption of $Q - Q_1$ and an increase in price of $P_0 - P_1$ is measured by the areas $P_0 j b P_1$ plus $bja$. The area $P_0 j b P_1$ represents a transfer from consumers to producers (mainly producers in unaffected regions) because of the higher price of chicken meat/eggs after the disease outbreak, while area $bja$ represents a deadweight loss. The total loss to Australian society equals the loss to the producers in the affected area plus the loss to all consumers minus the transfer from consumers to producers because of an increase in the price of chicken meat.

The area $aij$, representing loss to producers ($LPS$), could be measured by measuring and then adding the triangular areas of $ijm$ and $jma$ (figures 3c and 4). While measuring area $jma$ is straightforward, the area $ijm$ could be measured by subtracting area $imn$ from the

Figure 4: Effect of END on the Australian chicken meat and egg markets
area \( inj \) (figure 3c). An expression to measure \( LPS \) was derived in this manner and is given in equation 2:

\[
LPS = \frac{1}{2} (Q_0 k p_o)
\]

where \( k \) is the vertical shift in the aggregate supply curve measured as the vertical distance between the parallel portions of the two supply curves, and \( p_o \) is the proportion of the annual production in the affected area lost due to disease.

The loss to the consumers, \( LCS \) (areas \( P_1 b j p_0 \) plus \( bja \)), can be estimated using the following formula:

\[
LCS = \Delta P Q_1 + 0.5 \Delta P \Delta Q
\]

However, a part of \( LCS \) given in equation 3 (or the loss to consumers) would be a transfer to producers, which is given by, \( TR \) (area \( P_0 j b P_1 \)):

\[
TR = \Delta P (Q_1 - 0.5 * Q_0 p - \Delta Q))
\]

where \( p \) is the proportion of the annual aggregate production lost due to disease.

Total loss to the Australian society, \( TL \) (areas \( aij \) plus \( bja \)), is given by:

\[
TL = LPS + (LCS - TR).
\]

Estimation of the economic costs of Newcastle disease

Changes in equilibrium quantities and prices due to a Newcastle disease outbreak in a perfectly competitive chicken meat market are measured in this study using a multimarket approach because of the close interrelations between individual meat markets. The tool used in this study to measure changes is an elasticity version of ABARE’s Econometric Model of Australian Broadacre Agriculture (EMABA) which models the Australian meat market as a system of individual meat markets. EMABA’s meat market system includes separate markets for poultry, beef and veal, lamb, mutton, pork, and ham and bacon. The approach outlined in the preceding section was then used to calculate economic losses of a Newcastle disease outbreak.
Modifications to EMABA

The poultry component of EMABA's meat market system was modified for the purpose of this study. A series of experiments was conducted with the model to estimate equilibrium quantities and prices of chicken meat after the disease outbreak, using variable length of run supply curves.

EMABA models demand, supply, trade and price determinations for seven commodities of which meats are the more important (see Dewbre, Shaw, Corra and Harris 1985 for a detailed description). Equations have been estimated using annual data while production adjustments by meat producers over a number of years are captured through dynamic relationships. The Australian poultry market component of EMABA models chicken meat demand as a function of the price of chicken meat, prices of other meats, and three exogenous variables (consumer price index, consumption expenditure and population). Supply is taken as infinitely elastic, assuming producers can adjust relatively quickly to within year changes in demand. The price of chicken meat is modelled as a function of feed and other costs (Harris and Shaw 1992). An infinitely elastic chicken meat supply, as modelled in EMABA, means that the producer share of any economic gains approaches zero over the time period considered.

Even though broiler production has an eight week production cycle, the assumption that chicken meat producers complete adjustment within a year following a price change may be unrealistic. Using quarterly data for the United States, Chavas and Johnson (1982) found that supply is most responsive (with an elasticity of 0.61) at the initial broiler placement stage. Supply was somewhat responsive (with an elasticity of 0.19) after seven months at hatching stage. Very little adjustment (with an elasticity of 0.06) is made as a response to price change during the next eight week broiler production period. Though the entire production process takes ten months, they found that production adjustments in the US broiler industry would increase from zero in the very short run (at the very beginning) to about 95 per cent of the longer term adjustment in the intermediate run (after three years); the long run equilibrium finally reached about five years after a price change. The longer term for chicken meat supply should be sufficient for the response in investments to price change to be realised in the adjustment of output.

The Australian chicken meat market component of EMABA was modified to incorporate a supply relationship with price responses to varying lengths of run. In log-linear differential form, the supply relationship was defined as:
where $Q_{st}$ is quantity of chicken meat supplied in time $t$, $P_t$ is price in year $t$, $p$ is a proportional horizontal shift in supply, and $e_n$ is the supply elasticity with respect to change in price corresponding to the supply curve with $n$ length of run measured in years.

Following Yotopoulos and Nugent (1976), $e_n$ is defined as:

$$ (7) \quad e_n = e^* [1 - (1 - \lambda)^n] $$

where $e^*$ is the long term supply elasticity and $\lambda$ is the coefficient of adjustment.

In the elasticity version of EMABA, chicken meat demand is defined as:

$$ (8) \quad d(lnQ_{dt}) = \sum \eta_{ci} d(lnP_{it}) + \sum \psi_j d(lnZ_{jt}) $$

where $Q_{dt}$ is the quantity of chicken meat consumed in year $t$, $P_{it}$ is price of meat $i$ in year $t$, $Z_{jt}$ is exogenous variable $j$ (consumer price index, population and consumption expenditure) in year $t$, $\eta_{ci}$ is elasticity of chicken meat demand with respect to change in $P_{it}$, and $\psi_j$ is elasticity of chicken meat demand with respect to change in $Z_{jt}$.

The chicken meat price determination equation in EMABA where price is assumed to be a function of feed prices and prices of other inputs is replaced with a competitive market clearing identity:

$$ (9) \quad Q_{st} = Q_{dt} $$

A new chicken meat supply relationship was not estimated. The supply elasticities corresponding to different lengths of run were estimated for a long term elasticity of 2 assuming an adjustment coefficient of 0.6. Using quarterly data and employing a Nerlovian partial adjustment model, Bhati (1987) has estimated the adjustment coefficient for chicken meat at 0.17. Since in the long run a complete adjustment,

$$ (10) \quad (1-\lambda)^n = 0 \text{ is achieved,} $$

this means that the long run equilibrium in chicken meat supply would be obtained in around twenty quarters (five years). This confirms the finding of Chavas and Johnson
(1982) reported earlier in this section. The coefficient of adjustment which may be calculated using annual data should be larger than the estimate obtained with quarterly data. A coefficient of adjustment of 0.6 led to an almost complete adjustment in a five year period.

Economic cost of Newcastle disease

Table 2 details the economic costs in the first five years after an outbreak of Newcastle disease in the chicken meat industry. The estimates are calculated assuming no imports. The estimated total loss in the short run to Australian society (\$50 million a year) due to a 15 per cent reduction in chicken meat production is equivalent to almost 4 per cent of the estimated gross value of chicken meat production at the retail level in 1992-93 (\$1500 million). The components of the short run economic impact of the disease in the chicken meat sector are: a consumer loss of \$101 million due to higher prices, a producer loss of \$42 million in affected areas, and a producer gain of \$93 million in unaffected areas due to higher prices.

The estimated net total loss falls each year with the increasing length of run for supply adjustment. Any increase in the price of chicken meat would be smaller each year with the increasing length of run for supply adjustment, leading to a decline in the producer loss in the affected area, consumer loss and the producer gains in the unaffected areas. Though it is not estimated in this study, based on the argument for a perfectly elastic supply for chicken meat, the estimated economic effects should approach zero in the long run.

<table>
<thead>
<tr>
<th>Year</th>
<th>Consumer loss</th>
<th>Net total loss</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$m</td>
<td>$m</td>
</tr>
<tr>
<td>1993</td>
<td>42</td>
<td>50</td>
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<tr>
<td>1994</td>
<td>28</td>
<td>34</td>
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<td>1995</td>
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<tr>
<td>1996</td>
<td>21</td>
<td>26</td>
</tr>
<tr>
<td>1997</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>135</td>
<td>164</td>
</tr>
</tbody>
</table>

Table 2: Economic effects of a Newcastle disease outbreak in chicken meat industry

Present day values a in 1993 dollars

<table>
<thead>
<tr>
<th>Year</th>
<th>Consumer loss</th>
<th>Net total loss</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$m</td>
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<td>21</td>
<td>26</td>
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<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>135</td>
<td>164</td>
</tr>
</tbody>
</table>

a Calculated at a discount rate of 8 per cent. b Comes about because the prices to both consumers and producers would increase.
In this study, the present day value of the total losses of $164 million aggregated over the five year period implicitly assume that effects of the disease are dissipated after five years.

References


