THE OPTIMAL LOCATION OF EGG
PRODUCTION IN NEW ZEALAND

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State control associated with the egg industry is not peculiar to New Zealand, and has been the subject of investigations and debates in a number of countries. In fact, such control in the New Zealand context is currently under investigation by the Industries Development Commission.

One aspect of control is its effect on the location of the egg producing industry in New Zealand. The model presented in this report is used as a tool to address the question of what additional costs are incurred by the egg industry due to the locational rigidities imposed by the present conditions associated with the production Entitlement system.

While this question is only one implication of control, quantification of such implications is necessary if the industry is to continue to examine the efficiency of its own industry structure.

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P.D. Chudleigh
Director
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Any opinions expressed in this Report are those of the authors and do not necessarily reflect those of the New Zealand Poultry Board, its members or staff.
SUMMARY

The operation of production control in the New Zealand egg industry has tended to result in the sub-optimal location of production facilities. This study was instigated to: (i) determine the optimal location of egg production throughout New Zealand; (ii) estimate the potential cost savings to the industry and consumers through the relocation of production facilities closer to the optimal pattern, and; (iii) review some of the possible policy alternatives which could be used to facilitate a more efficient location of production.

The approach taken was to develop a transshipment model of the New Zealand egg industry, accounting for egg production costs, transfer costs and egg demand patterns, for twenty regions throughout the country. Using the model, the theoretical optimal production pattern was determined under a range of cost and production assumptions. The general conclusion was that significant savings, mainly resulting from reduced transport and handling costs, would be possible if regional supply and demand could be matched more closely; in particular, a reduction in the transfer of eggs from the South Island to the North Island would appear desirable. Using existing, underutilised production facilities a saving of about $715,000 per annum was indicated through the more efficient location of production. Allowing for new production facilities to be built where necessary, a further saving of $676 thousand per annum (approximately $1.4 million in total) was indicated. The optimal location of production was found generally to be insensitive to changes in feed price relativities and transport costs; however, the potential savings possible were affected by these costs.

Various policy options are discussed which could facilitate a more efficient location of production. It is concluded that there would be advantages in allowing market forces to act, through tradeable production Entitlements, to achieve a more efficient industry structure.
CHAPTER 1

INTRODUCTION

1.1 Aims of the Study

The current location of egg production throughout New Zealand has largely been determined by the 1970 Egg Marketing (Production Entitlement) Regulations, now incorporated into Poultry Board Regulations (1980), which were introduced to minimise unprofitable surplus production. The entitlement scheme (and subsequent developments of it) depends on restricting the number of laying birds held by producers and has led to a closer matching of total national supply and demand; however, the significance of regional imbalances has increased. As a result of changes in transport costs, population densities and costs of production throughout New Zealand, it appeared that the current location of production could be resulting in unnecessary costs to the industry, associated with the transportation of eggs from surplus to deficit areas.

The first aim of this study, therefore, was to determine the optimal location of egg production throughout New Zealand, accounting for transport costs, population densities and production costs. The second aim was then to estimate the potential savings to the industry and consumers from moving toward the optimal location of production. Given that such savings were found to be significant and a move toward a more efficient production pattern was justified, then production would have to be reduced in some areas and increased in others. The method and rate of these changes will be important; while a rapid move to a more efficient pattern of production would be expected to lead to a more rapid realisation of the benefits, there are other issues to be considered. A policy of rapid change may be counter productive if it causes undue hardship for some producers or leads to a serious disruption of supply. The third aim of this study was, therefore, to examine alternative methods of achieving changes in the location of production, in the light of the benefits and costs involved.

1.2 Industry Background

1.2.1 Production.

The N.Z. commercial egg industry comprises approximately three million laying birds producing about 60 million dozen eggs per annum on some 500 poultry farms scattered throughout New Zealand with particular concentrations in Christchurch, Hastings, Tauranga and Auckland. Poultry farmers supply the bulk of their produce to egg floors for grading, packaging and distribution to retailers. There are 19 egg floors operating in New Zealand under license to the Poultry Board.
The commercial egg industry is augmented by backyard producers who operate on a much less intensive scale but still contribute some 15 million dozen eggs annually, all of which are consumed within New Zealand. Demand for commercially produced eggs is seasonal, suffering a summer slump, due to the effect of backyard production which peaks at this time.

Since the introduction of the entitlement scheme in 1970, mandatory and voluntary reductions in gross entitlements have been used by the Poultry Board to minimise production surpluses. Nearly all farmers reduce their operative entitlement voluntarily in return for reduced levies. This has led to a change in husbandry techniques with less intensive use of shed facilities. Most regions could accommodate an increase in entitlement by using existing shed facilities but beyond this limit, additional birds would have to be housed in new and more expensive sheds. New management techniques coupled with new facilities would allow more economical use of feed, and other inputs, but the problem of higher capital investment to attain these economies remains.

Feed requirements can vary between regions depending on climatic conditions, but this effect has largely been overcome by efficient housing design. Feed rations for the industry are usually calculated for each region by the feed companies using least-cost formulations which satisfy nutrition requirements. Compared with grain, which comprises approximately 70-80 percent of the cost of all feed mixes, other ingredients have little impact on the total cost of feed. Transport costs play a significant role in the costing of grain as grain production is concentrated around the Waikato, Hawkes Bay, Manawatu, Canterbury, Otago and Southland areas while egg production is distributed throughout N.Z.

1.2.2 Distribution.

Although there is an overall surplus of eggs, variation in regional supply and demand requires that eggs must be moved around the country to satisfy demand in all regions. Surplus eggs are processed, at a cost to the industry, into unpasteurised pulp which is sold to the local baking trade, and pasteurised pulp and egg powder which are exported. Although most egg floors manufacture unpasteurised pulp, only three egg floors in New Zealand are capable of processing eggs for export. Some surplus eggs therefore must also be transferred between egg floors for processing. The net cost of transporting and processing eggs is passed on to all farmers by way of a levy on their operative entitlement.

Most eggs produced on poultry farms are distributed through the closest egg floor; however, farmers can deliver to more distant egg floors if they bear the cost of transport or, if they are outside nominated egg marketing areas, they can sell eggs direct to the public or to retailers.

When eggs are received at an egg floor they are graded prior to resale or transfer and a commission is charged for this service. This applies even if the eggs received at an egg floor have been consigned from another egg floor although the commission charged is smaller than
if they have been consigned directly from the farm. Hence, depending on whether the eggs are transferred between egg floors, extra commission may be incurred. Typically 1 percent of eggs received from farms must be dumped as of no commercial value. Additional losses of approximately 1 percent occur for eggs transferred between egg floors due to increased age and damage from extra handling and travel. Another 5-6 percent of gross receipts are fit only for processing into pulp or powder. At each egg floor, sufficient eggs must be available to satisfy retail demand, including an extra quantity to cover the distribution of demand through the grades. Eggs surplus to retail demand must either be processed into pulp or powder or transferred to another egg floor. One of the functions of the N.Z. Poultry Board, under the Poultry Act of 1976 is "to ensure, as far as possible, a sufficient supply of eggs and their equitable distribution in the general interests of producers and consumers". In practice this means that the Poultry Board endeavours to supply all grades of eggs to all regions at all times; to achieve this objective the Poultry Board targets a shell egg surplus of up to five million dozen eggs annually. A significant proportion of the surplus is ultimately processed for the domestic bakery trade.

1.2.3 Entitlement policy.

In 1979/80 the Government completed a survey of the N.Z. egg industry and recommended that the industry should remain controlled. In addition, it set a price of $5.00 per bird on sales of entitlements, which could only be sold to the Poultry Board. This price remained valid until 31 July, 1981 at which time the price dropped to $2.50 per bird. This price was maintained until 31 July, 1982, after which time entitlements were deemed to have no value. The effect of this decision was that many entitlement holders considering leaving the industry, or holding unused entitlement license, sold their entitlements back to the Board before 31 July, 1981. These sales to the Board allowed 287,000 entitlements to be withdrawn from the industry. The Poultry Board have subsequently proposed to the Government an alternative system of entitlement transfer under which entitlements would still only be able to be surrendered to the Poultry Board, but a price would be paid by the Poultry Board for any entitlements received and they would be redistributed to deficit areas. The proposal is currently under Government scrutiny and seems likely to be accepted.

1.3 Important Aspects of the Industry

1.3.1 Feed supply.

The cost of feed accounts for just over 50 percent of the total cost of egg production on a typical poultry farm. Feed rations are normally based on a least-cost feed mix that satisfies known nutritional requirements. Many grains (and meatmeals) are available for the mix. The energy requirement of the ration forces 70-75 percent by weight of the feed mix to be composed of one or more grains (and meatmeals). The remaining 25-30 percent of the feed mix is composed of a large number of ingredients present in very small amounts to guarantee hen health, shell strength, yolk colour, etc. The total cost
of these ingredients makes up approximately 35 percent of the total cost of feed. Since the cost of non-grain ingredients varies only slightly between regions, feed costs are highly dependent upon grain prices.

Grain prices do vary significantly between regions, due to the different types of grain grown and used in each region, and the high costs of transporting grain. For example, maize production is concentrated in the North Island areas of Waikato, the Bay of Plenty, East Coast and Hawkes Bay; wheat and barley production are concentrated in Canterbury, Otago, Southland, Wanganui and Manawatu, while oats production is concentrated in Canterbury and Southland.

Obviously, grains are not grown for use by the egg industry alone. Wheat, for example, must be offered to the Wheat Board and if the quality is acceptable the wheat will be processed into flour. The byproducts of this process, notably bran and pollard, can then be sold to the feed industry for use in feed. The feed industry mixes feeds for laying hens, meat poultry, pigs, and other animals. The price of layer feed thus depends on a complex mix of grain production, the competing demands by other industries, and grain transport costs. The price of layer feed will also depend on the pricing policy of the individual feed firms and this depends upon the objectives of the feed miller as to profits and market share, and competition from rival feed millers. Some feed millers attempt to set one price for the season, while others work more closely to a cost-plus system, with frequent price rises throughout the year. Some feed millers include delivery in the quoted price, others quote an ex-factory price only, and others will deliver free within a limited distance, and at a subsidised rate outside this distance.

Some poultry farms do not purchase already-mixed feed, but purchase the ingredients and mix their own feed. Such activity is treated as extra business activity outside the ambit of this report.

1.3.2 Methods of egg transport.

On the farm, eggs are gathered at least daily and stored in cool stores. They are then transported by truck at least twice weekly to the egg floors where they are again stored at cool temperatures awaiting grading, packaging, and redistribution to retailers. Direct supply of eggs from poultry farms to egg floors in other regions occur in some cases with an associated saving in commission charges. Egg losses occur through rough handling, and egg quality deteriorates with time, much more rapidly at hotter temperatures. To ensure that eggs reaching the consumer are of high quality, egg transfers should be fast and in refrigerated vehicles.

Many egg floors will receive eggs that are surplus to their current requirements. These surplus eggs must be disposed of either by processing into one or more of the three egg byproducts (unpasteurised pulp, pasteurised pulp and powder), or by transference to another egg floor for resale or processing. As it is not economic to transfer small numbers of eggs, eggs must accumulate until a batch of sufficient
size to justify transferral is attained. As a consequence of this short delay egg quality may suffer, although any such effect is likely to be minimal as eggs are stored under cool conditions during this period.

Rail transport of eggs has many disadvantages because rail wagons are not refrigerated, and at each end of the journey eggs must be handled on and off trucks. The rail service may also be subject to delays. All these factors cause physical losses during the transfer of eggs, as well as the less tangible drop in quality of retail grade eggs. Road transport is quicker - once the truck is filled it can leave immediately and travel directly to its destination. Road transport also allows the use of refrigerated vehicles, and reduces handling; consequently, where possible and feasible, licences have been obtained to transport eggs by road.

At present eggs are transferred, throughout the country, in the following manner:-

(i) North Island.
Eggs are transported between egg floors by road.

(ii) South Island.
Eggs are transported by rail between South Island egg floors with the exception of consignments to and from Nelson, for which road transport is used.

(iii) Inter Island.
Transfers of eggs between the South and North Island, excluding some to and from Christchurch, are made by rail-ferry. Recently sea shipping of eggs from Christchurch to Wellington and Auckland has become possible. At present about 75 percent are consigned by sea and 25 percent by rail-ferry.
CHAPTER 2

THE MODEL AND SOLUTION TECHNIQUE

2.1 Model Summary

To determine the optimal location of egg production throughout New Zealand a computer model was developed. For this purpose the country was divided up into 20 regions corresponding to the 18 egg floors operating throughout N.Z. (combining the two egg floors operating in the Auckland area), with additional regions for the areas around Ōamaru and Greymouth. The regions cannot be combined as most egg floors accept and redistribute eggs within separate and identifiable regions. The fate of each region, particularly each egg floor, was also a matter of interest. The processing of surplus eggs must also be identified with a specific egg floor, as the disposal cost of surplus eggs depends to a large degree on the transportation costs of shifting the surplus to its final destination.

Feed and other production costs were determined for each region together with the costs of transporting eggs and pulp between all regions. The various levels of transportation are:

(i) Eggs from poultry farms to local and distant egg floors.

(ii) Eggs between egg floors to satisfy retail demand and meet processing requirements.

(iii) Unpasteurised pulp between egg floors to meet local demand.

Having estimated these costs the model was run to determine the least-cost location of production to minimize total production and transport costs, subject to the requirement that the demand for eggs be met in all regions at all times.

2.2 Linear Programming

The technique chosen was to model the egg production and distribution system using linear programming (LP). Problems suited to analysis with linear programming are generally those where an optimal allocation of scarce or limited resources is sought to meet stated objectives, and where all relationships between variables are, or can be assumed to be, linear, and the function to be optimised is also linear.

The formulation of an LP model requires the distillation of the operations of a system into terms of linear algebraic equations, relating the essential elements of the system to each other. The mathematical formulation of the model is presented in Section 2.4.
2.3 Model Structure

2.3.1 Model formulation assumptions.

Key assumptions made in the formulation of the model relate to the following aspects of the problem:

(i) The number of regions

For ease of modelling and computation, it is desirable to keep the number of regions in a transshipment problem to a minimum. However, for validity the number of regions must be sufficient to accurately reflect actual production and transfer patterns. The model results will be used to suggest a new location pattern for egg product, thus existing concentrations of egg production and their likely future production levels were important in determining regions for the transshipment model. Egg production was grouped into areas corresponding to the egg floors with distribution costs dependent on the number and location of these egg floors. For the model 20 regions were defined corresponding to the 18 egg floors operating throughout New Zealand (combining the two egg floors operating in the Auckland area), with additional regions specified for the areas around Oamaru and Greymouth. These regions are identified by the name of the city or town in the region possessing an egg floor. In Appendix 1 each region is defined in terms of local government areas.

(ii) The time period of the model

Model results will be used by the egg industry as an aid to management in the long-term relocation of commercial egg production throughout New Zealand. This use suggests a yearly time period for the model, as daily and weekly fluctuations are not of immediate relevance; however, seasonal supply and demand fluctuations within the year must be considered. Although hens have a definite laying cycle, fluctuations in commercial egg supply are minimal as most poultry farms produce with several flocks. Thus commercial egg supply was assumed constant throughout the year.

Demand for commercial eggs, however, does fluctuate significantly throughout the year due mainly to the effect of backyard production. The increased backyard production of eggs during the summer months leads to decreased demand for commercially produced eggs during this period. Thus, although an egg floor may, on an annual basis, have perfect balance of supply and demand, during the course of a year it may be necessary to both transfer eggs into and out of the floor. The associated transport costs are a vital component of the total cost of the New Zealand commercial egg industry, and cannot be ignored in any analysis of the industry.

Decreasing the time period of the model to, say, 6 months, to cope with seasonality would have increased the model size proportionately, making the model too large to solve economically. Therefore, an annual model was chosen, but allowance was made for the fluctuations in demand that cause many egg floors to transfer eggs both into and out of the floor during the course of a year. The size of such transfers is a function of the relationship between local supply and demand in a
region. This relationship was established for each region by analysing historical data and relating, using regression techniques, the transfer pattern with supply and demand. The resulting functions were incorporated into the model as transfer constraints.

(iii) Heterogeneity of eggs

Eggs are graded at the egg floor, before sale, into six grades and the payout to poultry farmers varies with these grades. Four grades are eggs suitable for normal retail sale and are graded on the basis of weight. Another grade is for eggs of "processing" quality - fit for human consumption but non-standard weights and/or possessing minor quality defects. The final category is "no-value" eggs, which are unfit for human consumption. Thus to producers, to the egg floors, and to consumers 'eggs' are not one product; rather 'eggs' consist of a few product lines differentiated one from the other on the basis of weight and quality.

When creating a model of any system there is constant conflict between introducing more variables to further define the system, and reducing the number of variables to reduce computational effort and costs and facilitate easy interpretation of the system. For this model the heterogeneity of the various egg grades is important because it is necessary to ensure that at each egg floor there are sufficient quantities of all grades available to meet retail demand and that sufficient quantities of eggs of less-than-retail quality are processed into byproducts.

To allow for this in the model, eggs are treated as a homogeneous product but the requirement is imposed that enough eggs are supplied to ensure the availability of all grades for retail sale and to ensure the processing of sufficient eggs into byproducts. Thus the model size is kept down, and the important aspect of egg heterogeneity is accounted for (see Sections 2.4 and 3.10 for further detail).

(iv) Direct and gate sales

The level of direct egg supplies to retailers and gate sales is mainly dependent on the distribution of poultry farms in a region. As most regions already have specific areas where most poultry farms are located (and are likely to remain so) it was assumed that direct sales and gate sales remain at their present levels unless total production in a region drops to less than twice the level of these sales.

(v) Egg demand

A survey carried out by the Poultry Board (pers. comm.) between 1979 and 1981, showed no differences between regions in the level of total egg demand (commercial and backyard) throughout New Zealand. Thus the demand for commercially produced eggs in each region was estimated using known population statistics (N.Z. Dept. of Statistics) and Poultry Board estimates of backyard production.
2.3.2 The objective function.

The problem was to determine the optimal pattern of egg production and distribution which meets all demands for all egg products at the least cost to the industry. Thus the objective function used in the model was to minimise the total cost to the industry which includes the cost of egg production, the cost of egg transport from farm to egg floor and between egg floors, and the cost of pulp transfer between egg floors.

2.3.3 Transportation networks.

The egg production and distribution system is modelled as a series of five transport networks. The initial network of the model is the allocation of grain from various supply sources to egg production regions, where the grain is consumed and converted into eggs. Egg production in each region has been split into two sources to allow for differences in the cost of production associated with existing versus new facilities. Production costs for new facilities accounts for the high capital cost of new poultry housing and the reduced grain requirement due to the increased operating efficiency of new poultry housing. Any differences in egg quality due to the standard of poultry housing is insignificant and the egg production in each region can be recombined.

The second network of the system relates to the transfer of eggs from poultry farms to egg floors. For such transfers an allowance is made for a small proportion of eggs which are lost to the system at grading due to breakages and poor quality. Farm produced eggs may be sold directly to consumers from the farm gate, and in areas not designated as licensed Egg Marketing Areas eggs may also be sold directly to retailers. Allowance is made for these options in the model.

Eggs must also be transferred between egg floors to satisfy all regional demands. Due to the increased delay before grading, and the extra handling, such transfers incur greater losses than the direct transfers from poultry farm to egg floor. This is the third transportation network.

The fourth transportation network arises from the need to move eggs between egg floors for processing. Retail demand is satisfied through egg floor sales, but there are always surpluses of eggs at egg floors as a result of grading. Such eggs are either unfit for sale as whole eggs but acceptable for processing, or are of acceptable quality for sale but surplus to demand. Processing facilities for powder, pasteurised pulp and unpasteurised pulp are limited (see Table 1), therefore eggs must be transferred between egg floors to allow for processing.

The fifth and final transportation network is the allocation of unpasteurised pulp from the producing egg floor to the regions of demand. The model ensures that domestic demand for unpasteurised pulp is also met.
### TABLE 1

**Surplus Processing Plants at Each Egg Floor**

<table>
<thead>
<tr>
<th>Egg Floor</th>
<th>Unpasteurised Pulp</th>
<th>Pasteurised Pulp</th>
<th>Egg Powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whangarei</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auckland</td>
<td>Yes</td>
<td>Yes</td>
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</tr>
<tr>
<td>Hamilton</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tauranga</td>
<td>Yes</td>
<td></td>
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</tr>
<tr>
<td>Rotorua</td>
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<td>Yes</td>
</tr>
<tr>
<td>Gisborne</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Hastings</td>
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</tr>
<tr>
<td>New Plymouth</td>
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</tr>
<tr>
<td>Wanganui</td>
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<tr>
<td>Palmerston North</td>
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<td>Invercargill</td>
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### 2.4 Mathematical Formulation

The industry activities can be specified in terms of 13 groups of decision variables:

- $F_i$: feed supplied from grower region $i$
- $F_{Tij}$: feed transported from grower region $i$ to producer region $h$
- $P_j$: total eggs produced in producer region $j$
- $X_j$: eggs produced in producer region $j$ using existing shed facilities.
- $Y_j$: eggs produced in producer region $j$ using new shed facilities.
- $D_j$: eggs sold in producer region $j$ by poultry farms directly to consumers and retailers.
- $P_{Tjk}$: eggs transported directly from poultry farms in producer region $j$ to egg floor $k$
- $EFDEM_k$: demand for eggs from egg floor $k$
 eggs transferred from egg floor $k$ to egg floor $l$

$E_k$ eggs processed by egg floor $k$

$BT_{kl}$ eggs sent from egg floor $k$ to egg floor $l$ for processing

$PA_k$ pasteurised pulp processed at egg floor $k$

$PO_k$ powdered egg processed at egg floor $k$

$PU_{kl}$ unpasteurised egg processed at egg floor $k$ and transported to egg floor $l$

Constraints are specified as follows:

(1) Feed Supply Balance: the amount of grain transported to producers from grain growers equals the amount of grain used from that region, i.e.,

$$\sum_{i=1}^{20} F_{ij} = \sum_{j=1}^{20} \alpha_{ij} F_{ij}$$

(2) Feed Use Balance: the amount of grain used in a producer region is directly related to the production using old and new sheds in that region, i.e.,

$$\alpha_1^j X_j + \alpha_2^j Y_j = \sum_{i=1}^{20} \alpha_{ij} F_{ij}$$

where $\alpha_1^j =$ amount of grain required to produce 1000 dozen eggs using existing sheds, and

$\alpha_2^j =$ amount of grain required to produce 1000 dozen eggs using new sheds.

(3) Farm Production Balance: total egg production in a producer region is equal to the sum of production using existing and new sheds, i.e.,

$$X_j + Y_j = P_j$$

(4) Farm Sales Balance: egg production is either transported to an egg floor, or sold directly to consumer or retailer, i.e.,

$$P_j = D_j + \sum_{k=1}^{20} PT_{jk}$$
(5) Direct Sales Constraint: direct sales (by poultry farm to consumers and/or retailers) are limited to a proportion of total egg production, i.e.,

\[ D_j \leq d_j P_j \quad j = 1, 2, \ldots, 20. \]

where \( d_j = (0.5, \) for those regions that have a physical egg floor; \( 1.0, \) otherwise.

(6) Commercial Demand Balance: demand for eggs is met by direct sales and sales through the egg floor, i.e.,

\[ D_k + EFDEM_k = CDDEM_k \quad k = 1, 2, \ldots, 20. \]

where \( CDDEM_k \) = total demand for eggs in egg floor region

(7) Net Receipts Balance: eggs received at the egg floor that have commercial value and can be sold or processed is slightly less than the amount of eggs consigned to the egg floor, i.e.,

\[ NR_k = (1-nv_1) \sum_{j=1}^{20} PT_{jk} + (1-nv_2) \sum_{l=1, l \neq k}^{20} XFER_{lk} \quad k = 1, 2, \ldots, 20. \]

where \( nv_1 = 0.008, \) the proportion of eggs having no value after consignment direct from poultry farm to egg floor.

\( nv_2 = 0.01, \) the proportion of eggs having no value after consignment between egg floors.

(8) Grade Availability Constraint: sufficient whole eggs must be received at the egg floor to meet a distribution of demand different to the distribution of supply, i.e.,

\[ NR_k \geq (1+s_k)EFDEM_k \quad k = 1, 2, \ldots, 20. \]

where \( s_k \) = proportion by which supply must exceed demand.

(9) Egg Floor Balance: eggs received at the egg floor must be resold, consigned to another egg floor in a state fit for resale, or processed into surplus, i.e.,

\[ NR_k = EFDEM_k + \sum_{l=1}^{20} XFER_{kl} + \sum_{l=1, l \neq k}^{20} ET_{kl} \quad k = 1, 2, \ldots, 20. \]

(10) Surplus Balance: Eggs that are to be processed into pulp or powder must be processed either at the local egg floor or after transportation to another egg floor, i.e.,

\[ E_k = \sum_{j=1}^{20} ET_{jk} \quad k = 1, 2, \ldots, 20. \]
(11) Downgrades Availability Constraint: A certain proportion of net receipts is fit only for processing into pulp or powder, i.e.,

\[
\sum_{i=1}^{20} ET_{kl} + E_k \geq pulp\ NR_k
\]

where \( pulp = 0.0566 \), that proportion of net receipts downgraded as fit for processing only.

(12) Egg Floor Transfers in Constraint: Transfers into an egg floor are directly related to the local supply where the function relating transfers to local supply is estimated by simulating for various levels of local supply, i.e.,

\[
(1-nv_1) PT_{j,k} + (1-nv_2) \sum_{j=1}^{20} \sum_{j \neq k} XFER_{j,k} \geq a_k^T \left( (1-nv_1) PT_{kk} + D_k \right) + b_k^T
\]

where \( a_k^T \) and \( b_k^T \) are the coefficients of local supply and a constant estimated from the simulation.

(13) Egg Floor Transfers Out Constraint: Transfers out from an egg floor are directly related to the local supply, where the function relating transfers to local supply is estimated by simulating for various levels of local supply, i.e.,

\[
\sum_{l=1}^{20} XFER_{kl} + \sum_{l \neq k} ET_{kl} \geq a_k^O \left( (1-nv_1) PT_{kk} + D_k \right) + b_k^O
\]

where \( a_k^O \) and \( b_k^O \) are the coefficients of local supply and a constant estimated from the simulation.

(14) Surplus Processing Balance: Surplus eggs generated at the egg floor or received from another egg floor must be processed into pasteurised pulp, unpasteurised pulp or powder, i.e.,

\[
\sum_{l=1}^{20} ET_{lk} = \beta_{pa} PA_k + \beta_{pc} PO_k + \beta_{pu} \sum_{l=1}^{20} PU_{kl}
\]

where \( \beta_{pa} = (1, \text{if egg floor } k \text{ possesses a pasteurised pulping plant.} \) (0, otherwise.

\( \beta_{pc} = (1, \text{if egg floor } k \text{ possesses a powdered egg plant.} \) (0, otherwise.

\( \beta_{pu} = (1, \text{if egg floor } k \text{ possesses an unpasteurised pulping plant.} \) (0, otherwise.)
(15) Unpasteurised Pulp Sales Balance: The demand for unpasteurised pulp must be met, i.e.,

\[
\sum_{k=1}^{20} PU_{k1} = PUSAL_{1} \quad i = 1, 2, \ldots, 20.
\]

where \( PUSAL_{1} \) = demand for unpasteurised pulp from egg floor

(16) National Surplus Constraint: To ensure demand is met at all times a national surplus is required, i.e.,

\[
\sum_{j=1}^{20} P_{j} > NS + \sum_{j=1}^{20} CDEM_{j}
\]

where \( NS \) = the national surplus of supply over demand.

(17) Rate of Change Constraint: It is desired in some instances to constrain change to no more than a certain rate, i.e.,

\[
\sum_{j=1}^{20} Y_{j} \leq MAXY
\]

where \( MAXY \) = the maximum annual change, expressed in new shed facilities.

The variables are subject to the following bounds:

(1) \( \Sigma_{i} \leq MAXF_{i} \quad i = 1, 2, \ldots, 20. \)

where \( MAXF_{i} \) = amount of grain that can be supplied from within grain growing region \( i \) at the existing price.

(2) \( X_{j} \leq MAXX_{j} \quad j = 1, 2, \ldots, 20. \)

where \( MAXX_{j} \) = egg producing capacity using existing sheds in producer region \( j \).

(3) \( D_{j} \leq MAXD_{j} \quad j = 1, 2, \ldots, 20. \)

where \( MAXD_{j} \) = current direct sales in the region served by egg floor \( j \).

(4) \( E_{k} \geq MINE_{k} \quad k = 1, 2, \ldots, 20. \)

where \( MINE_{k} \) = minimum surplus that must be processed at egg floor \( k \).
16.

\[ E_k \leq \text{MAXE}_k \quad k = 1, 2, \ldots, 20. \]

where \( \text{MAXE}_k \) = maximum surplus that can be processed at egg floor \( k \).

The objective may be stated as:

\[
\begin{align*}
\text{Min} & \quad \sum_{i=1}^{20} f_i x_i + \sum_{i=1}^{20} f_{ij} X_{ij} + \sum_{i=1}^{20} y_i Y_i + \sum_{i=1}^{20} \sum_{j=1}^{20} t_{jk} P_{T,ijk} \\
& \quad + \sum_{k=1}^{20} \sum_{l=1}^{20} \sum_{l \neq k} t_{kl} (X_{\text{FER},kl} + ET_{kl}) + \sum_{k=1}^{20} \sum_{l=1}^{20} \sum_{l \neq k} p_{U} p_{U,kl} P_{U,kl} \\
\end{align*}
\]

where

- \( f_i \) = cost of grain in grain region \( i \)
- \( f_{ij} \) = cost of transport of grain from grain region \( i \) to producer region \( j \)
- \( X_{ij} \) = cost of production of eggs using existing sheds.
- \( Y_{ij} \) = cost of production of eggs using new sheds.
- \( t_{jk} \) = cost of transport of eggs directly from poultry farms in producer region \( j \) to egg floor \( k \)
- \( t_{kl} \) = cost of transport of eggs between egg floors \( k \) and \( l \)
- \( p_{U} \) = cost of transport of pulp between egg floors \( k \) and \( l \)

The units of measurement are:

(i) Eggs - 1 thousand dozen eggs.

(ii) Feed - 1 tonne grain.

(iii) Costs - 1 dollar.

2.5 Potential Uses for the Model

In addition to facilitating this production location study, the development of the transshipment model provides the New Zealand egg industry with an instrument to assist in other long-term planning. Some potential uses of the model include the regular monitoring of the effects of changes in feed costs, transport costs and population densities. Also the model could be used to investigate the effects of entitlement transfers, the addition or removal of egg floors, the relocation and/or removal of egg processing facilities, and differing national surplus targets.
CHAPTER 3

DATA AND PARAMETER ASSUMPTIONS

3.1 Cost of Feed

Long-term regional feed price relativities will be important in determining the optimal egg production location; however, without a detailed study of the New Zealand stock-feed industry only limited data are available in this area. In the absence of better information the assumption was made that future price relativities would be similar to those that have occurred in the recent past. The results of the analysis should be interpreted in the light of this assumption and further research may be justified in this area.

Clearly a consistent data base, with which to compare regional feed prices, was essential. To this end the major feed suppliers were surveyed to obtain information relating to plant location, basic feed prices, discounting policy and delivery charges. This information was then used, in conjunction with the proportion supplied by each supplier, and the location of farms supplied, to determine an average on-farm feed price for each region. The distance of farms from the feed supplier was accounted for in these regional prices. ¹

While an effort was made to derive accurate on-farm feed prices (as at June 1983), it is inevitable that these prices and, consequently, feed price relativities will change over time. To test the sensitivity of production location to changes in feed price relativities, some sensitivity analysis was undertaken by running the model with varied feed price relativities.

3.2 Feed Availability

Feed availability may be an important factor in determining the rate at which existing production patterns can change; however, as with feed costs, little information is available in this respect. For example, in some areas local feed production is insufficient for stock-feed requirements and feed must be bought in. It is, however, difficult to determine where this feed comes from, and, more importantly, whether more feed would be available at the current price. Because of the uncertainty about feed availability and cost, the model was run without any restriction on feed availability i.e. it was assumed that, if necessary, feed would be available for increased production without changing past price relativities. Model results were then examined in the light of this assumption.

¹ The information made available by feed manufacturers was confidential and neither it nor the derived regional on-farm feed prices can be published.
3.3 Non-Feed Costs of Production

A representative budget, prepared by the Ministry of Agriculture and Fisheries (M.A.F.) Poultry Division, for a 10,000 bird farm was used as the basis for the calculation of the net cost of production. Regional production costs were estimated for both existing and new facilities. This was necessary to allow the option, within the model, of increasing production in regions where this increase would necessitate the building of new facilities. For the purposes of the model the net cost was defined as the total cost of production (with the exception of feed costs) less the revenue from the sale of by-products. This net cost is expressed as cost per 1,000 dozen eggs produced.

With respect to housing costs, poultry production and housing experts (W. Gay, R. Patchell, pers. comm.) believe that producers in less favourable (colder) climates have largely compensated for this by providing better insulated housing for birds. Therefore, climatic variation was accounted for by altering bird housing costs, rather than production rates and feed conversion ratios. Hence the bird environment and productivity was assumed to be independent of location. The net effect, in the model, was uniformity of production parameters throughout New Zealand but slightly higher housing costs in regions with unfavourable climatic conditions.

The budget items exhibiting significant regional variation are listed below. (More detail is provided in Appendix 2.)

(i) **Housing** - housing in warmer areas tends to be enclosed, but needs less insulation than those in cooler areas. All need ventilation control. The model incorporates variation in capital expenditure based on increasing insulation costs, from north to south.

(ii) **Land values, rates and rents** - these costs are mainly dependent upon demand from alternative land uses, and distance from centres of large population. Parameter estimates were based largely on information supplied by the Farm Management and Rural Valuation Department of Lincoln College.

(iii) **Insurance and depreciation** - these costs are influenced by the size of investment in housing and land. They were estimated as a function of these two investment parameters.

(iv) **Electricity** - this item accounts for lighting, ventilation and both cooling and heating. It is assumed to vary with climatic (in particular temperature) conditions.

Differences between production costs for new and existing facilities were due largely to the capital outlay required to build new housing. However this outlay is partially balanced by a decrease in some of the operating costs (e.g. electricity).

Total non-feed costs estimated for each region are presented in Table 2.
### TABLE 2

**Non-Feed Production Costs**

<table>
<thead>
<tr>
<th>Region</th>
<th>Existing Facilities</th>
<th>New Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$/1,000 doz. eggs</td>
<td>$/1,000 doz. eggs</td>
</tr>
<tr>
<td>Whangarei</td>
<td>540</td>
<td>581</td>
</tr>
<tr>
<td>Auckland</td>
<td>530</td>
<td>570</td>
</tr>
<tr>
<td>Hamilton</td>
<td>556</td>
<td>598</td>
</tr>
<tr>
<td>Tauranga</td>
<td>543</td>
<td>586</td>
</tr>
<tr>
<td>Rotorua</td>
<td>545</td>
<td>586</td>
</tr>
<tr>
<td>Gisborne</td>
<td>544</td>
<td>585</td>
</tr>
<tr>
<td>Hastings</td>
<td>545</td>
<td>586</td>
</tr>
<tr>
<td>New Plymouth</td>
<td>553</td>
<td>595</td>
</tr>
<tr>
<td>Wanganui</td>
<td>547</td>
<td>588</td>
</tr>
<tr>
<td>Palmerston North</td>
<td>550</td>
<td>592</td>
</tr>
<tr>
<td>Masterton</td>
<td>551</td>
<td>593</td>
</tr>
<tr>
<td>Wellington</td>
<td>535</td>
<td>575</td>
</tr>
<tr>
<td>Nelson</td>
<td>550</td>
<td>592</td>
</tr>
<tr>
<td>Christchurch</td>
<td>545</td>
<td>586</td>
</tr>
<tr>
<td>Greymouth</td>
<td>600</td>
<td>645</td>
</tr>
<tr>
<td>Ashburton</td>
<td>563</td>
<td>606</td>
</tr>
<tr>
<td>Timaru</td>
<td>563</td>
<td>606</td>
</tr>
<tr>
<td>Oamaru</td>
<td>559</td>
<td>601</td>
</tr>
<tr>
<td>Dunedin</td>
<td>558</td>
<td>600</td>
</tr>
<tr>
<td>Invercargill</td>
<td>559</td>
<td>601</td>
</tr>
</tbody>
</table>

---

### 3.4 Feed Coefficients of Egg Production

Grain consumption and production rates were assumed constant throughout New Zealand. It follows that the feed coefficients of egg production, specified in terms of weight of feed per 1,000 dozen eggs produced, were also constant. These parameters were estimated by the Ministry of Agriculture and Fisheries Poultry Division for both existing and new facilities. Production rates and feed conversion ratios both improve with the use of new facilities, reflecting the better bird environment provided by improved housing. Feed conversion ratios and production rates are presented in Table 3.
TABLE 3

Feed Conversion Ratios and Production Rates

(a): Production Parameters for Existing Facilities

<table>
<thead>
<tr>
<th>Feed required t/1,000 dozen eggs</th>
<th>Eggs produced per hen per year</th>
<th>Feed per hen per day (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.498</td>
<td>250</td>
<td>118</td>
</tr>
</tbody>
</table>

(b): New Facilities

<table>
<thead>
<tr>
<th>Feed required t/1,000 dozen eggs</th>
<th>Eggs produced per hen per year</th>
<th>Feed per hen per day (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.372</td>
<td>254</td>
<td>113</td>
</tr>
</tbody>
</table>

3.5 Egg Transfer Costs

3.5.1 Intra-Island.

Eggs are transported by road within the North Island. The costs of egg transfers between North Island egg floors were supplied by the Poultry Board.

Eggs were assumed to be transported by rail between South Island egg floors with the exception of consignments to and from Nelson, for which road transport is used. Costs for most routes were available from the Poultry Board. Those not available were calculated using the New Zealand Railways' schedule of freight charges. Rail transport of eggs was charged at Class 'D' rates and the return of empty crates at Class 'C' rates. Because the cost of rail transport is weight dependent, it was assumed that an average crate weighed 28.5 kgs and was capable of holding 30 dozen eggs. Freight charges from depot to railhead and vice versa were included in the rail transport costs.

3.5.2 Inter-Island.

Transfers of eggs between South and North Islands, excluding those from Christchurch, were assumed to be made by rail-ferry. Once in the
rail-ferry system, eggs generally continue to North Island egg floors by rail. Again egg freight was charged at Class ‘D’ rates and empty crate returns at Class ‘C’ rates. The crates used are collapsible and capable of holding 420 dozen eggs. Crate returns from Picton to any South Island egg floor were costed as free in accordance with actual practice.

With respect to transfers from Christchurch, during 1983/84 about 75 per cent were consigned by sea and 25 per cent by rail. These proportions were used to derive composite transfer costs between Christchurch and North Island egg floors.

3.6 Direct Transfers

Generally a producer will send eggs to the egg floor in the same region as his farm. While direct transfers to egg floors in other regions are possible, it is generally not a practical or economic option for most producers who must bear the cost but gain little or no benefit. Thus, despite the fact that increased direct transfers could reduce industry costs through reduced commission charges, direct transfers of eggs from farms to other than local egg floors were constrained in the model to match historical direct transfer patterns.

3.7 Direct Sales and Total Production of Eggs

Poultry farms are often clustered together on poor land. It can reasonably be assumed that any increase in a region’s production of eggs will be produced on existing or new farms in the same locality. Direct sales primarily depend upon the proximity of the poultry farm to the consumer, thus any increase in production may not affect the current level of direct sales unless direct demand is currently unsatisfied. This is not the case in any region, as poultry farms in all regions consign considerable quantities of eggs to egg floors. (The exception is Greymouth where there is no egg floor.) Within the model, restrictions were imposed to limit the quantity of eggs supplied directly from producers to consumers and retailers. Direct sales, as a proportion of total production, were limited as follows:

(1) In regions with an egg floor; a maximum of 50 per cent.
(2) In regions not having an egg floor; a maximum of 100 per cent.

3.8 Loss of Quality During Transport

All eggs that are not sold directly to consumers and retailers are graded before sale into eight categories at the last egg floor to handle the eggs (see Section 2.3.1). When considering the transportation of eggs, account must be taken of the loss of quality during transport; there are two factors to consider. Firstly, some eggs may be broken or deteriorate in quality to the extent that they are unfit for human consumption. These eggs are ‘lost’ to the industry. Secondly, upon grading (and/or regrading) some eggs will be down-graded from retail quality to commercial quality. These eggs
cannot be used to meet retail demand.

The effect of these factors was determined by using Poultry Board records to survey past consignments of eggs from poultry farms to egg floors, and between egg floors. Transfers of eggs between egg floors may be of two types - either graded eggs, where the quality loss can be measured directly, or ungraded eggs where the quality loss can only be measured indirectly. Most eggs are transferred in graded form thus an accurate estimate can be made of the loss of quality due to transfer.

Variation in loss of quality was found to be minimal with respect to the distance travelled. The loss of quality could be adequately described by three parameters - one each to define the proportion of "no-value" eggs upon direct transfer from poultry farm to any egg floor (0.8 per cent), and between egg floors (1.0 per cent) and one for the proportion of consumable eggs received at the egg floor found fit for processing only (5.66 per cent).

3.9 Regional Commercial Demand for Eggs

From October 1979 to September 1981 the New Zealand Poultry Board conducted a monthly survey of New Zealanders' egg consumption. Every month a different sample of 500 households throughout New Zealand was surveyed to find out household details and the household's purchases and usage of eggs over the previous week. It was found that consumption per person did not vary significantly throughout New Zealand during the Survey. The national average was 290 eggs per head per annum, which includes an allowance for eggs consumed as 'prepared' foods (restaurant meals, take-aways, etc.). The assumption was made that this consumption average has not changed significantly over time.

Using the latest population figures available from the Department of Statistics it was possible to estimate total annual regional consumption of eggs. These eggs are supplied both by the commercial egg industry (as administered by the New Zealand Poultry Board) and by the "backyard" egg industry which consists of all other egg production within New Zealand. Estimates of production/hen provided by the MAF, and the known commercial hen population in each region, were then used to calculate the total annual commercial production of eggs in each region. Direct sales are the residual of commercial production after allowing for known transfers to egg floors (including direct inter-regional transfers). Egg floor sales of commercially produced eggs in each region are known exactly. The demand for commercially produced eggs in each region is the sum of egg floor sales and direct sales. The balance of total demand is filled by "backyard" production.

3.10 Surplus Receipts Necessary to Meet Demand Peculiarities

Egg floors receive fresh ungraded eggs from poultry farms and grade them according to rigid criteria as to weight and quality. The egg floor has no control over the grades of eggs received, therefore it is necessary for the egg floor to receive extra eggs to ensure that the consumer retains the choice of all grades of eggs at all times.
The Poultry Board maintains records of receipts and retail sales by grade on a four-weekly basis. To avoid undue emphasis being placed on unusual circumstances, the third-highest surplus receipts indicated by an examination of the 13 observations in 1981/82 (a representative year) was used as the required surplus necessary to meet demand peculiarities.

3.11 Coefficients for Constraints Relating Transfers to Local Supply and Demand

Local supply is defined as local direct sales plus net transfers directly from poultry farms within the region to the local egg floor. Although local supply may exceed local commercial demand on an annual basis, transfers into the egg floor may still be necessary during the year in order to meet seasonal demand peaks. (If local commercial demand exceeds local supply on an annual basis, transfers into the egg floor will definitely be necessary during the year.) Similarly, transfers out of an egg floor must be made when the excess supply exceeds the processing facilities available at that egg floor. The minimum necessary transfer of eggs from an egg floor in any one week is that which reduces the excess supply to the maximum level which the egg floor is capable of processing as surplus. Such transfers may occur as eggs for resale (graded and/or ungraded) and/or for processing.

The transport costs of such transfers are an important component of the total cost of operating the industry and the amount and cost of such transfers cannot be ignored. Using historical demand patterns for each region and simulating for various levels of local supply it was possible to estimate the necessary transfers into and out of each egg floor on a weekly basis, and aggregate these to give the annual total. Ordinary Least Squares Regression was then used to express the level of annual transfers into each egg floor as a function of annual local supply. The regression equations formed the basis of the transfer constraints.

3.12 National Surplus

Production levels can be altered but the process takes time. To increase production hens must be reared from chicks to "point of lay" - a process that takes five months. To decrease production there are more options, but care must be taken that production will not need to be increased soon afterwards.

At present the New Zealand Poultry Board resets targeted production levels infrequently by the determination of hen entitlements for every poultry farm in the country. This is achieved by the calculation of a single figure: the "operative" entitlement. The operative entitlement is expressed as a percentage of the gross entitlement, an historical figure directly related to the poultry farm's carrying capacity when entitlements were first introduced in 1970. The targeted production level is set to meet the variable demand for all grades in all areas of the country at all times. This is currently believed to require a target national surplus of five million dozen eggs. The actual level of national surplus will depend upon
sales.

3.13 Egg Production Bounds

New Zealand Poultry Board inspectors visit all poultry farms throughout New Zealand to inspect poultry housing, refrigeration equipment and hen numbers. As part of the inspection the existing shed capacity of each farm is measured. Coupled to regional egg production figures, and allowing for the desirability of some unused capacity for husbandry reasons, it was possible to calculate the potential for regional egg production using existing poultry housing.

3.14 Surplus Processing Constraints

Reductions in national production in the last ten years has reduced the amount of processing carried out at egg floors and left excess processing capacity. The assumed maximum surplus that could be processed at each egg floor was, therefore, arbitrarily assessed at 150 per cent of the maximum processed for the two years 1978/79 and 1979/80.
CHAPTER 4

RESULTS

4.1 Introduction

Prior to estimating the optimal location of production it was necessary to establish, for purposes of comparison, a model representation of the current location of production based on estimates of current regional production. Current regional production was defined to be the aggregate commercial egg production in a region. This production can be:–

(1) sold directly to consumers through either gate or retail sales
(2) consigned from farms to the local egg floor
(3) consigned from farms to egg floors outside the region.

Estimated current regional production and current major direct transfers were used as inputs to the model to provide the 'benchmark' run. The results of this run provided an approximation of current industry operating costs and as such provided a base with which to compare alternative location strategies. This estimated cost is likely to be a lower limit on the current industry cost because it assumes that egg and pulp transfers are made in the optimal (least cost) way, which in practice may not always be the case.

In order to estimate regional production levels it was necessary to know regional bird populations. To estimate regional bird populations, known base entitlement levels were adjusted to allow for the effect of entitlement adjustments and voluntary reductions in flock sizes. These estimated regional bird populations were then used in conjunction with production rates to derive current regional production. The Poultry Board supplied information relating to both current direct transfers and regional entitlement levels.

4.2 Optimal Location with Existing Facilities

4.2.1 Summary.

Due to the reduction in bird numbers associated with the operation of the Entitlement Scheme, most areas have some excess production capacity. The model was run initially to determine the extent of savings possible in the short-term using this capacity only.

A potential saving of about $700,000 per annum (or about 1.2 cents per dozen eggs produced) compared with the 'benchmark' situation was indicated through the more efficient location of production utilising existing production facilities. To achieve this saving, the model
results indicated that the Islands should become almost self-sufficient in the supply of eggs. Only minimal inter-island transfers of eggs would occur and these only from Christchurch to Wellington. A production increase of 7 per cent in the North Island, and a decrease of 18 per cent in the South Island was indicated by the model. Within both Islands regional supply and demand were matched more closely, thereby decreasing egg transfers between regions and their associated costs. Significant increases in production were indicated for Auckland, Hamilton, Hastings, Palmerston North and Wellington, with significant decreases for Tauranga, Christchurch and Oamaru. The potential saving can be collapsed into component form as follows:

Savings due to:

(a) less commission charges: $410,000
(b) less freight costs: $265,000
(c) less production costs: $40,000

Total potential savings: $715,000

A more detailed description of the results of the analysis is presented in the following section on a region by region basis. Both major and minor transfers for the optimal solution are shown. In most cases minor transfers are balancing transfers used to offset seasonal demand fluctuations for eggs. ‘Direct transfers’ refer to transfers to the egg floor directly from farms in other regions. The analysis was undertaken assuming the current location of pulping and pasteurising plants; it is possible, however, that further savings may be achieved through relocating these plants.

4.2.2 North Island: Optimum production and transfers.

Whangarei
- Production 1350 thousand dozen (+ 23% change)
- Direct Transfers
- Inter-floor Transfers 1100 from Auckland

Comment: Whangarei production expands to the limit of its existing capacity but still requires transfers from Auckland.

Auckland
- Production 17300 (+ 13%)
- Direct Transfers
- Inter-floor Transfers 1100 to Whangarei

Comment: Auckland production increases to meet local demand for eggs and to supply the shortfall in Whangarei’s supply. The production increase makes transfers in, either direct or indirect, unnecessary.
Hamilton

- Production
  Direct Transfers 4400 (+19%)
  Inter-floor Transfers 450 to Rotorua

Comment: Hamilton production increases at the expense of direct transfers from farms in Tauranga, Wanganui and Rotorua regions. In addition, no direct transfers are made from farms in Hamilton to egg floors in other other regions. The 'total available' eggs under current production is 3,700 while under the optimal production plan it is 4,400, of which 450 are then transferred to Rotorua.

Tauranga

- Production
  Direct Transfers 3000 (-50%)
  Inter-floor Transfers 200 to Rotorua

Comment: Production in Tauranga contracts significantly. This is largely due to the fact that regions, such as Auckland and Hamilton, currently receiving eggs transferred from Tauranga, become more self-sufficient under optimal conditions.

Rotorua

- Production
  Direct Transfers 1000 (+25%)
  Inter-floor Transfers 450 from Hamilton
  200 from Tauranga
  600 from Gisborne
  1300 from Hastings

Comment: Production in Rotorua increases to the maximum possible, given existing capacity. Local demand is still markedly higher than supply, necessitating transfers in from several regions.

Gisborne

- Production
  Direct Transfers 1600 (+23%)
  Inter-floor Transfers 600 to Rotorua

Comment: Production increases in Gisborne, the excess being freighted to Rotorua to help meet the shortfall in supply. Despite Gisborne being relatively isolated from major centres of demand, relatively low production costs make transfers to Rotorua feasible.

Hastings

- Production
  Direct Transfers 4700 (+24%)
  Inter-floor Transfers 1300 to Rotorua
  600 to Wellington
Comment: Production in Hastings increases to offset deficit supplies in both Rotorua and Wellington. Hastings' location makes it well suited to supplying these two regions. It is worth noting that Hastings is currently a surplus region. Despite this, it would appear that, using only existing facilities, increased production in Hastings would be justified.

New Plymouth

- Production: 2100 (no change)
  - Direct Transfers
  - Inter-floor Transfers: 200 to Wellington

Comments: Production in New Plymouth does not change significantly. Excess production is freighted to Wellington to help meet that region's supply shortfall.

Wanganui

- Production: 1800 (+6%)
  - Direct Transfers
  - Inter-floor Transfers: 200 to Wellington

Comment: Wanganui becomes a source of supply to Wellington.

Palmerston North

- Production: 3300 (+22%)
  - Direct Transfers: 1480 to Wellington
  - Inter-floor Transfers: 220 to Wellington

Comment: Palmerston North remains an important source of supply to meet the Wellington deficit.

Masterton

- Production: 1300 (+18%)
  - Direct Transfers
  - Inter-floor Transfers: 400 to Wellington

Comment: Also an important source of supply for the Wellington market.

Wellington

- Production: 3700 (+23%)
  - Direct Transfers: 1480 from P. North
  - Inter-floor Transfers: 600 from Hastings
  - 200 from New Plymouth
  - 200 from Wanganui
  - 400 from Masterton
  - 220 from P. North
  - 150 from ChCh
Comment: Wellington production increases by 23 per cent representing the extent of increase possible with existing facilities. Substantial transfers into Wellington come from Hastings, New Plymouth, Wanganui, Palmerston North, Masterton and Christchurch.

Given that the North Island currently has two main deficit regions, Rotorua and Wellington, these results are logical. Where possible local supply has changed to meet local demand. In regions without sufficient production capacity to meet local demand, transfers of eggs have come from the most efficient sources. A large improvement in efficiency appears possible by merely allowing production increases in the Wellington and Rotorua regions.
### 4.2.3 South Island: Optimum production and transfers.

**Nelson**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>1500 thousand dozen (-17% change)</td>
</tr>
<tr>
<td>Direct Transfers</td>
<td>-</td>
</tr>
<tr>
<td>Egg Floor Transfers</td>
<td>300 to Greymouth</td>
</tr>
</tbody>
</table>

**Comment:** Production in Nelson contracts to supply local demand and meet the West Coast (Greymouth) shortfall in supply.

**Christchurch**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>6900 (-20%)</td>
</tr>
<tr>
<td>Direct Transfers</td>
<td>-</td>
</tr>
<tr>
<td>Inter-floor Transfers</td>
<td>150 to Wellington</td>
</tr>
<tr>
<td></td>
<td>100 to Ashburton</td>
</tr>
</tbody>
</table>

**Comment:** Christchurch production falls to supply local demand and help meet the demand for eggs in Wellington and Ashburton. It is primarily the advent of sea freight for eggs that makes Christchurch an efficient source of supply for Wellington.

**Greymouth**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>70 (+25%)</td>
</tr>
<tr>
<td>Direct Transfers</td>
<td>-</td>
</tr>
<tr>
<td>Egg Floor Transfers</td>
<td>300 from Nelson</td>
</tr>
</tbody>
</table>

**Comment:** Production increases as far as existing capacity will allow. Despite this increase in production, substantial transfers from Nelson are necessary to meet local demand.

**Ashburton**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>28 (+22%)</td>
</tr>
<tr>
<td>Direct Transfers</td>
<td>-</td>
</tr>
<tr>
<td>Inter-floor Transfers</td>
<td>100 from ChCh</td>
</tr>
<tr>
<td></td>
<td>300 from Timaru</td>
</tr>
</tbody>
</table>

**Comment:** Production increases to the limit of existing capacity but substantial transfers from Christchurch and Timaru are still necessary to meet local demand.

**Timaru**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>930 (+24%)</td>
</tr>
<tr>
<td>Direct Transfers</td>
<td>200 from Oamaru</td>
</tr>
<tr>
<td>Inter-floor Transfers</td>
<td>300 to Ashburton</td>
</tr>
</tbody>
</table>

**Comment:** Production increases to satisfy local demand and demand in the Ashburton region. Timaru is currently a surplus region. Although an overall increase in production is suggested, this is more than offset by increased transfers out.
Oamaru
- Production
  Direct Transfers
  Egg Floor Transfers
750 (-58%)
200 to Timaru
200 to Dunedin

Comment: Oamaru as a source of eggs for the Wellington market is replaced by sources closer to Wellington.

Dunedin
- Production
  Direct Transfers
  Egg Floor Transfers
1900 (-12%)
200 from Oamaru

Comment: Production in Dunedin contracts in favour of transfers from Oamaru.

Invercargill
- Production
  Direct Transfers
  Inter-floor Transfers
1550 (-3%)

Comment: Production contracts slightly to satisfy only local demand.

The major changes to production location are the significant reductions in production in Oamaru and Christchurch. This results because South Island transfers to Wellington are largely replaced by sources closer to Wellington. Other alterations to South Island regional production levels are due to a better matching of regional supply and demand, thereby reducing transfer costs.

4.3 Allowing New Production Facilities

To examine the further savings possible in the longer term, the model was re-run allowing new facilities to be built in any region if they resulted in a reduction of the overall industry cost. The results indicated that a further $670 thousand per annum ($1.39 million or 2.3 cents per dozen, in total) potential savings were possible through relocation of production into existing and new facilities. The additional savings involve the following components:

Savings due to:

(a) less commission charges: $367,000
(b) less freight costs: $286,000
(c) less production costs: $23,000

Total additional savings: $676,000
FIGURE 1: Regional Production Levels Under Differing Operating Conditions
FIGURE 1 Cont: Regional Production Levels Under Differing Operating Conditions
Once again savings due to lower overall production costs constitute only a minor part of total possible savings. Production was increased through the use of new facilities in Whangarei, Rotorua, Wellington, Greymouth, Ashburton and Timaru. The levels of regional production under: (i) current conditions; (ii) optimal relocation using existing facilities; and (iii) optimal relocation allowing new facilities are shown in Figure 1.

4.4 Explanation of Results

There are a number of regions with a shortfall between local supply and local demand. The cheapest way of getting eggs to an egg floor is, generally, to produce them locally. The model operates by first identifying deficit supply regions and then selecting the most cost efficient method of meeting these deficits.

When the model was constrained to allow no new facilities, production in deficit regions was expanded using existing facilities. If this production increase was still insufficient to meet demand, transfers from other regions were selected. The criteria for selection was that the most cost efficient transfers were chosen first. For example, Wellington production was expanded to its maximum existing capacity and transfers, mainly from Hastings, New Plymouth, Wanganui, Palmerston North and Masterton, were used to meet the remaining shortfall in supply. As a result, production in these areas tended to increase in the short-term.

When the model was allowed to use new facilities, production in deficit areas expanded further. The result was a closer matching of regional supplies and demands, thereby minimising transfers between regions. For example, through the use of new facilities, Wellington became largely self-sufficient in eggs. Consequently, production contracted in regions, which in the short-term, had been sources of eggs for Wellington. As a result production in Hastings, New Plymouth, Wanganui, Palmerston North, Masterton and Christchurch dropped in the long-term.

4.5 Sensitivity Analysis

4.5.1 New facilities in Wellington.

Due to problems of land availability and feed supply the extent to which production in the Wellington area would be able to increase, as a result of new production facilities, is uncertain. To investigate this, the model was re-run constraining the amount of new facilities in Wellington. New facilities were constrained to an additional 10 per cent of the current production capacity. Constraining new production facilities in Wellington adds about $200 thousand to the unconstrained cost. This additional cost comprises the following components:

Cost due to:

(a) increased commission charges: $76,000
(b) increased freight costs: $87,000
(c) increased production costs: $38,000
Total extra cost: $201,000

The major difference between this run and the unconstrained run was that Wellington would no longer be self-sufficient in eggs. Transfers in would still be required from Hastings, New Plymouth, Wanganui, Palmerston North, Masterton and Christchurch. Consequently, production in these regions would not contract to the extent suggested when no restrictions were made on new facilities in Wellington.

4.5.2 Reduction in shipping charges.

The model results indicated egg transfers from Christchurch to Wellington of 150,000 dozen when current shipping charges and existing production capacities were used. To investigate the effect a reduction in shipping charges would have on relocation policy, the model was re-run with reduced shipping costs. The shipping costs from Christchurch to both Auckland and Wellington were reduced by 10 per cent and 25 per cent. Neither of these reductions changed the optimal relocation strategy or the level of Christchurch-Wellington transfers.

The shipping cost from Christchurch to Wellington would have to fall by about 30 per cent before there would be any effect on the optimal relocation strategy. A reduction of this magnitude would increase transfers from Christchurch to Wellington at the expense of production in Hastings i.e. Christchurch would begin to replace Hastings as a source of supply to Wellington.

4.5.3 Feed price relativities.

Feed costs account for just over 50 per cent of the total cost of egg production on a typical poultry farm. Regional feed price relativities, rather than actual feed prices, will influence relocation strategies. Of particular interest is the influence of feed price relativities between the North and South Islands, in determining optimal relocation policies. As at June 1983 the average on-farm price of feed in the South Island was $271/tonne and in the North Island $297/tonne. The price differential between the two Islands was, therefore, $26/tonne. To investigate the effect of an increase or decrease in this differential, the model was re-run with varied South Island feed costs to provide differentials in the range $0-$100. Regional production was limited to existing capacity.

Transfers of eggs from the South to the North Island only occurred to supply Wellington. Table 4 shows optimal regional transfers into Wellington, for varied inter-island feed cost differentials. The feed price differentials in Table 4 are the levels at which regions either become, or cease to be, sources of supply for Wellington. In summary, for a differential:
TABLE 4

Responses to the Feed Price Differential Between North and South Islands (existing facilities)

<table>
<thead>
<tr>
<th>Differential between North and South Island $/tonne</th>
<th>Regions Supplying To Wellington</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0</td>
<td>Hastings, New Plymouth, Wanganui, Palmerston North, Masterton</td>
</tr>
<tr>
<td>$26</td>
<td>Hastings, New Plymouth, Wanganui, Palmerston North, Masterton, Christchurch</td>
</tr>
<tr>
<td>$30</td>
<td>Hastings, Wanganui, Palmerston North, Masterton, Nelson, Christchurch</td>
</tr>
<tr>
<td>$60</td>
<td>Hastings, Palmerston North, Masterton, Nelson, Christchurch, Oamaru</td>
</tr>
<tr>
<td>$94</td>
<td>Masterton, Nelson, Christchurch, Oamaru, Dunedin</td>
</tr>
</tbody>
</table>
37.

(1) $0 or less Christchurch is not an optimal source of supply.

(2) $26 shows the current differential level with Christchurch the only South Island supplier to Wellington.

(3) At $30 Nelson becomes a supplier to Wellington and New Plymouth is replaced as a source.

(4) At $60 Oamaru becomes a source of supply and Wanganui is replaced.

(5) At $94 Dunedin becomes a supplier to Wellington. Above this differential level, Masterton is the only North Island supplier to Wellington.

The quantities actually transferred into Wellington, from the various regions, are also dependent upon the feed price differential. As the differential becomes greater both the number of South Island egg floors supplying Wellington, and the quantity supplied by each, increases.

4.6 Conclusions

The results of this analysis suggest that the optimal solution requires that the North and South Islands become virtually self-sufficient in eggs.

The potential savings possible through relocation of production, into existing facilities, is about $700,000 per annum (1.2 cents per dozen). To achieve this saving North Island production would increase by 7 per cent and South Island production decrease by 18 per cent. Significant production cuts are suggested for Tauranga, Christchurch and Oamaru. Production increases are indicated for Whangarei, Auckland, Hamilton, Hastings, Wanganui, Rotorua, Gisborne, Palmerston North, Masterton, Wellington, Greymouth, Ashburton and Timaru. Despite this relocation, Wellington, Rotorua, Whangarei, Greymouth and Ashburton would remain deficit areas.

When the model was re-run allowing new production facilities, a further saving of about $670,000 per annum (making a total of about $1.4 million or 2.3 cents per dozen) was indicated. New facilities were used in previously deficit regions. Inter-regional transfers of eggs were needed mainly in response to the seasonality of demand.

The conclusions from the sensitivity analysis can be summarised as follows:

(1) Restricting new facilities in Wellington: The result was a drop of about $200,000 per annum in potential savings.

(2) Reduced shipping charges between Christchurch and Wellington: Reductions, in these charges, of up to 25 per cent had no effect on the optimal relocation strategy. The charges would have to drop by 30 per cent before there was any effect on the relocation strategy.
(3) Changes in the feed price differential between the North and South Islands. The differential would have to be at least $30 in favour of the South Island before the sources of supply to Wellington changed.

The value of possible savings is largely dependent upon regional feed price relativities and consequently may differ from year to year. However, it is clear a significant potential gain to the industry as a whole is possible.
CHAPTER 5

METHODS OF ACHIEVING A MORE EFFICIENT LOCATION OF PRODUCTION

5.1 Introduction

The main cause of what would appear to be a sub-optimal location of egg production throughout New Zealand is the equalised pricing system which allows transport costs to be distributed across all producers rather than borne directly by those producers who incur them. This leads to a situation where producers have no incentive to reduce production or move production closer to markets in order to reduce the costs to the industry as a whole. The situation is exacerbated when other production costs, such as feed and land costs, which are borne by the producer, favour areas remote from the major markets. This appears to be the situation in New Zealand where in some cases the production advantages of the South Island can be utilized to supply the North Island, without producers incurring the associated cost of transport.

There may be equity arguments in favour of an equalised price across the country; however, there is a conflict between equity and efficiency in this case. The equalised price represents a cross-subsidisation of producers remote from markets by producers close to markets, and a subsidy to the industry as a whole by consumers.

To achieve and maintain an efficient distribution of production in a regulated industry, such as the New Zealand egg industry, three conditions would appear to be necessary:

(a) A mechanism which ensures that individual producers directly reap the benefits and bear the costs associated with their location.

(b) A mechanism for facilitating the efficient relocation of production.

(c) And possibly, a means of compensating producers who suffer as a consequence of the relocation of production.

There would appear to be various policy options available to achieve a more efficient structure and minimise unnecessary costs for the producer and consumer. These broad options, together with the advantages and disadvantages of each, are discussed below:

5.2 Redistribution of Quotas by the Poultry Board Without Regional Pricing

This option would involve a system whereby entitlements, voluntarily sold or surrendered to the Board, could be redistributed to areas where an increase in production is justified. Such entitlements
could be offered initially to existing entitlement holders with excess production capacity thus allowing production to increase quickly and without the need for substantial capital investment. While such a policy would cause little disruption in the industry it is also unlikely to lead to a significant improvement in the efficient location of egg production throughout New Zealand. Such a policy would perpetuate the equalisation of transport costs across all producers and would thus not provide any incentive for producers to move closer to the major markets. Also the adjustment mechanism is likely to be slow as it relies on the somewhat random availability of entitlements. The problem of where to encourage and discourage production would have to be faced by the Board and demand patterns, production costs and transport costs would have to be constantly monitored by the Board so that entitlements could be reissued in an efficient way. Further discussion on the difficulties of efficiently reallocating production without using the influence of market forces is presented in Section 5.3.2.

5.3 Regional Pricing

The second policy option would be to introduce some form of regional pricing. Under such a scheme producers in each region would (eventually) reap all the benefits and bear the costs associated with the advantages and disadvantages of their location. Such a scheme would provide a positive incentive for production to move to deficit areas and a disincentive for production to continue in areas where there is a significant surplus of eggs. The scheme could be introduced gradually, say over five years, by imposing a surcharge on the Entitlement Levy paid in egg surplus regions calculated as a proportion of the cost of disposing or transporting eggs from those areas.

This surcharge could be paid as a Levy rebate to producers in those regions where there is a deficit of eggs and where production is to be encouraged. The proportion of the cost of disposing and transporting eggs from surplus areas covered by the surcharge could be increased gradually over the five years until at the end of that period producer returns in each region reflected only the costs and benefits of production in that region. Also over this period, if adjustment in the level and location of production is satisfactory, the Levy and surcharge paid by producers in what were once surplus production regions could be largely eliminated.

The question arises as to the appropriate number and geographic location of the regions in such a scheme. The analysis undertaken in this study would suggest that a substantial proportion of the potential benefits of the relocation of production could be achieved by operating a two region scheme with the North Island as one region and the South Island as the other. Such a system would appear to have administrative advantages because of the clear separation of the regions.

Another alternative would be a three region scheme with the North Island divided into two regions approximately north and south of Lake Taupo. The division of the North Island on this basis is also supported by the results of this study which indicate that, with the efficient location of production in the North Island, egg transfers
tend to occur within such regions rather than between them. A scheme involving more regions, perhaps to the extent of a region based on each egg floor, would have the advantage of more closely matching regional supply and demand; however administrative problems would be increased.

A regional pricing scheme would not preclude the possibility of transfers of eggs between regions if it was found that the production cost advantages in one region more than off-set the cost of transporting eggs to another region.

While a regional pricing scheme could be effective in providing the incentive to relocate production it is also necessary that this relocation of production is facilitated. Under a free market system producers can choose to set up production when and where they believe they will make the most profit. When production is controlled with production quotas (entitlements), one of two general systems is generally adopted to facilitate structural adjustment. Either entitlements are freely transferable or they are controlled by the Board.

5.3.1 Transferable entitlements.

Freely transferable entitlements are generally favoured by economists (see Beck, 1974; O'Connor, 1978; B.A.E., 1983, for example) because they allow producers who are efficient by virtue of their management and location to purchase entitlements from less efficient producers, so ensuring an increasing overall level of efficiency in the industry. Transferable quotas also have the advantage of providing those leaving the industry with some compensation. Transferable quotas will, however, only be effective if they are associated with a pricing scheme that adequately reflects the true costs and benefits of production in different locations. This was probably not the case when transferable entitlements were operating in New Zealand prior to August 1978, and it is possible that, under those circumstances, transferable entitlements did nothing to improve the efficiency of the location of egg production in New Zealand.

A criticism of freely transferable production entitlements and quotas sometimes relates to the high price that they often acquire. However, this price merely reflects the level of benefits that producers are getting from holding entitlements, and it is this price which facilitates the adjustment process. An entitlement buyer will only offer a price that still allows him to make a profit, while an entitlement seller will only accept a price that makes it worthwhile for him to leave the industry.

On equity grounds, producer boards may fear that transferable entitlements will become concentrated in the hands of a few large producers; however, this possibility could be avoided by maintaining a maximum limit on the number of entitlements that could be held by one producer or organisation; a maximum limit of 20,000 birds per producer exists at present.
5.3.2 Entitlements controlled by the Board.

Without transferable entitlements the problem of efficiently reallocating entitlements falls upon the Board. Lane and MacGregor (1979) in a study of quotas and quota values in Canada make the following comment on such a situation:

"Can a board whose primary function is to improve the marketing system for a commodity be, at the same time, sufficiently aware of and sensitive to continuing developments at the production level to do a better job of allocating production or marketing rights among its producers than individual producers can do themselves. Given the diversity of resources available to each farmer and the differences in their individual goals and objectives it is unlikely that a board's decisions could be as progressive and equitable as those made by producers themselves.

A quota allocation and transfer system that was fully controlled by a board would tend to reduce the transfer of quota among producers. If the possibility of realising any capital gain by relinquishing quota were eliminated, as it would be under this system, then farmers would have less incentive to dispose of their quotas and leave the industry. This would be especially true for low income producers since they would have less funds available to make the adjustment. To the extent that this system provides less incentive to transfer quota it would tend to impede structural adjustment within the industry."

An advantage (from a Board's point of view) of a system where the Board controls all transfer of entitlement, is that it enables the Board to exercise direct control over the nature and rate of structural adjustment in the industry. It would thus be attractive if the Board sets a high priority on maintaining a large proportion of relatively small farms in the industry and moderating the disruption caused by relocating production. The price, however, could be continued structural inefficiencies in the industry.

If such a policy were adopted in New Zealand it would be necessary to regularly monitor cost and demand factors in the industry to ensure that the reallocation of entitlements contributed to improving the efficiency of the industry. Despite constant monitoring, however, conflict between the Board and individual producers would seem inevitable as Board decisions were enacted. For example, the Board may wish to transfer available quota from a surplus to a deficit region, however, some efficient producers in the surplus region, by virtue of their cost structure, may be able to bear full transport costs and still supply a distant market competitively. Such producers could justifiably make a case for access to available quota.

5.3.3 Free market.

In the interests of a complete examination of alternative ways of achieving a more efficient distribution of egg production throughout New Zealand, the option of moving toward a free market should be mentioned. Arguments against the operation of a free market in egg
industries throughout the world tend to relate to problems of quality control, security of supply and the dangers of production becoming concentrated in the hands of a few producers. Advantages of a free market tend to relate to the notion that free and competitive enterprise promotes the most efficient location and method of production, and encourages rapid adjustment to changing costs, prices and demand patterns, while at the same time assuring a least-cost product to the consumer.

A recent Committee of Inquiry into Egg Marketing in Victoria (Australia) examined these issues and concluded that a move toward a free market for eggs would be appropriate in that State. (See the "First and Second Reports to the Minister of Agriculture" published by the Committee of Inquiry into Egg Marketing in Victoria). It is beyond the scope of this study to determine if a free market would be appropriate in New Zealand, however, it should be noted this would be one way of achieving a more efficient location of production.
CHAPTER 6

OVERVIEW AND CONCLUSIONS

The analysis indicated that a saving of the order of $1.4 million or approximately 2.3 cents per dozen is possible as a result of relocation of production in New Zealand. Such a saving would appear to make some structural adjustment in the industry worthwhile but raises important questions about how such adjustment might be achieved. Unfortunately, as is the case in many industries, the adjustment necessary to benefit the industry and the community as a whole must be borne by relatively few and it seems reasonable that these producers be given sufficient time and, in some cases, assistance to allow them to leave the industry in satisfactory circumstances.

The problems of how and when production in an industry should be encouraged or discouraged, and how and when producers leaving the industry should be compensated, are difficult issues. Basically two alternatives are available to handle these issues; either a Board must take on all the responsibility of planning and controlling structural adjustment; or some market forces must be allowed to act to encourage producers themselves, acting in their own best interest, to make the required adjustment.

If a Board takes on the responsibility of planning and controlling all structural adjustment they place themselves in an unenviable situation. Understandably, it would probably be easiest for the Board to maintain the status quo and only allow those changes that could be achieved with the minimum of disruption and dissonance; however, such a policy would be unlikely to achieve significant improvements in the efficiency of the industry structure and it is possible that, given continuing change in other parts of the economy, the industry might eventually be forced to restructure.

Alternatively, if the Board, in the long-term interests of the industry, actively pursued a policy of industry restructuring it would almost inevitably lead to some dissonance as producers in some areas appeared to be favoured over those in other areas. Also, if such a policy was to be effective, it would require a careful and continuing analysis of supply, demand and cost factors in the industry.

The option of allowing some market forces to operate in the form of regional pricing and transferable entitlements has the advantage of putting the major adjustment decisions back into the hands of the

2. It should be noted that this saving relates to relocation of production only and does not include perhaps more substantial savings that could result from other forms of structural change such as changes in the size distribution of producers.
individual producers while still allowing the Board to maintain some control over the adjustment process. Also the system automatically provides some compensation for producers leaving the industry because they can sell their entitlements. In effect, producers who are benefitting from a relocation of production are compensating those who could otherwise be disadvantaged.
REFERENCES


Lane, S.H. and M.A. MacGregor (1970), Quotas and Quota Values, School of Agricultural Economics and Extension Education. University of Guelph, Ontario, Canada.


47.
**APPENDIX 1**

**DEFINITION OF MODEL REGIONS**

<table>
<thead>
<tr>
<th>Name of Region</th>
<th>Code</th>
<th>Geographical Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auckland</td>
<td>AUC</td>
<td>Rodney C (excluding all areas north of Warkworth but including Warkworth), Waiheke C, Great Barrier Island C, Franklin C.</td>
</tr>
<tr>
<td>Tauranga</td>
<td>TAU</td>
<td>Te Arahā B, Thames - Coromandel D, Ohinemuri C, Tauranga C, Whakatāne D (excluding Kawerau B and Murupara B), Opotiki C.</td>
</tr>
<tr>
<td>Rotorua</td>
<td>ROT</td>
<td>Tokoroa B, Putaruru B, Kawerau B, Murupara B, Rotorua D, Taupo C.</td>
</tr>
<tr>
<td>Gisborne</td>
<td>GIS</td>
<td>Waipu C, Waikohu C, Cook C.</td>
</tr>
<tr>
<td>Hastings</td>
<td>HAS</td>
<td>Wairoa C, Hawkes Bay C, Waipawa D, Waipukurau D, Dannevirke C.</td>
</tr>
<tr>
<td>Masterton</td>
<td>MAS</td>
<td>Pahiatua C, Eketahuna C, Masterton C, Wairarapa South C, Featherston C.</td>
</tr>
<tr>
<td>Wellington</td>
<td>WEL</td>
<td>Horowhenua C, Hutt C.</td>
</tr>
<tr>
<td>Nelson</td>
<td>NEL</td>
<td>Marlborough C, Kaikoura C (excluding Kaikoura Comm), Golden Bay C, Waimea C.</td>
</tr>
<tr>
<td>Town</td>
<td>Code</td>
<td>Counties</td>
</tr>
<tr>
<td>------------</td>
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<td>ASH</td>
<td>Ashburton C.</td>
</tr>
<tr>
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<td>Strathallan C, Mackenzie C, Waimate C.</td>
</tr>
<tr>
<td>Oamaru</td>
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</tr>
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<td>Invercargill</td>
<td>INV</td>
<td>Lake C, Southland C, Wallace C, Fiord C, Stewart Island C.</td>
</tr>
</tbody>
</table>

**KEY**
- C = Geographic County
- D = District
- B = Borough
APPENDIX 2

REGIONAL VARIATION IN NON-FEED COSTS OF PRODUCTION

Introduction

Non-feed costs of production were estimated using a representative budget for a 10,000 bird farm prepared by the Ministry of Agriculture and Fisheries. Optimal production location is primarily influenced by cost variations between regions. Since much of the budget was representative of the country as a whole, only those non-feed production costs which vary regionally are outlined. This variation is largely due to climatic differences between regions although proximity to centres of population can affect rates and land values.

Cost Differences Due to Climate

Poultry housing in all regions was assumed to be closed to the weather, and ventilated. Insulation costs vary through the country. Cooler areas need insulation for protection from the cold, whereas areas where high summer temperatures are experienced need roof insulation for protection from the heat. Similarly the electricity requirements for ventilation, lighting and cooling are dependent upon regional location.

These costs were estimated (in 1983 dollars) using an average 'countrywide' figure adjusted on a regional basis. These were calculated as follows:

(i) Capital Invested in Poultry Housing.

Poultry farms normally consist of layer and growing sheds. The capital invested in these sheds depends upon the type and quantity of insulation used. To estimate capital investment in these sheds, an average farm's sheds were costed at replacement value. This 'base figure' was then adjusted to account for differences in insulation requirements necessary to counter regional climatic variations. These costs are shown in Table A1.
TABLE A1

Capital Invested in Laying and Growing Sheds
(Base figure $294,000)

<table>
<thead>
<tr>
<th>Region</th>
<th>Differential ($)</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whangarei</td>
<td>-9,700</td>
<td>284,300</td>
</tr>
<tr>
<td>Auckland</td>
<td>-9,700</td>
<td>284,300</td>
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<td>Hamilton</td>
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<td>284,300</td>
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<tr>
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<td>299,000</td>
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<tr>
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<td>299,000</td>
</tr>
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<td>303,700</td>
</tr>
<tr>
<td>Invercargill</td>
<td>+9,700</td>
<td>303,700</td>
</tr>
</tbody>
</table>

(ii) Cost of Lighting.

Poultry farmers are progressively moving towards a more enclosed environment for hens. Thus, for the purposes of the budget, it was assumed that electricity for lighting is used at 15-16.5 hours per day at an average of 10 lux incandescent. The minimum and maximum power use was costed on a yearly basis as follows:

(a) Minimum

\[ 2.5 \text{ kilowatts/hour} \times 15 \text{ hours/day} \times 7 \text{ days/week} \times 51 \text{ weeks of lay} = 13388 \text{ kilowatts at 7c/kilowatt} = $937 \]

(b) Maximum

This was calculated as for the minimum, except the lighting was taken at 16.5 hours per day = $1031

The maximum and minimum lighting costs were then averaged to arrive at a base cost. Since the cost of lighting varies regionally,
adjustments were then made to the base cost on a regional basis. The regional costs for lighting are shown in Table A2.

<table>
<thead>
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</tr>
<tr>
<td>Dunedin</td>
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<td>1091</td>
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</table>

(iii) Electricity for Ventilation and Cooling.

The base ventilation cost was first estimated. This took into account the average number of birds and the average cost of ventilation per bird. The cooling/heating cost varies across the country. The cooling/heating load was estimated in the following manner:

(a) The base ventilation cost was estimated.

(b) An outside temperature range was determined for each region within which shed temperature could be maintained at stress-free levels without artificial heating or cooling.

(c) Degree days outside these minimum and maximum temperatures were then determined on a regional basis.

(d) Finally, the costs associated with keeping the bird environment within the previously determined range were estimated on a regional basis.
The costs for ventilation and cooling are shown in Table A3.

<table>
<thead>
<tr>
<th>Region</th>
<th>Differential ($)</th>
<th>Cost ($)</th>
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