Exploratory study on the economic value of a closed farming system on Dutch dairy farms

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A closed farming system may prevent the introduction of infectious diseases on to dairy farms and could be a good starting point for the eradication of these diseases. In order to introduce a closed farming system, farmers need to be made aware of how these diseases are introduced into the herd. Farmers will be more likely to implement a closed farming system when the economic value is quantified and attractive. An exploratory study was carried out to investigate the technical and economic results of closed dairy farms. Farms that purchased cattle and/or shared pasture (defined as 'open' farms) differed in technical results from farms that did not ('closed' farms). The results of the discriminant analysis showed that the 'closed' farms incurred lower costs for veterinary services, had a lower average age at first calving and a higher birth rate per 100 dairy cows. A linear regression analysis was carried out to investigate the influence of the farming system on economic performance. Being 'closed' was found to increase the net profit by £0.31 per 100 kg of milk, or approximately £25 per cow per year or 5 per cent of the typical net return to labour and management (£1 = Dfl 2.80 in November 1996).

A MAJOR aim of the European Union (EU) livestock policy is to improve the health of farm animals in the member states. Preventive herd health control at farm level is considered to be the major tool to bring about this improvement. National borders are replaced by borders around individual farms implying that individual farmers are responsible for their animals' health. Farmers need to be aware of the risks and management opportunities in order to maintain or improve the health of the animals on their farms (Julicher and others 1993).

Dutch agriculture is characterised by an intensive animal production system. In the past few decades the concentration of animals as well as the number of national and international contacts, for example the import or export of live cattle, have increased considerably (Nagel 1995). Dutch animal production depends strongly on international markets and, together with the favourable geographical situation of the country, this results in the large scale import and export of animals and animal products, putting strong pressure on maintaining a good health status (Tazelaar and Gerats 1995).

Statistics for 1994/95 show that there were approximately 1·7 million dairy cows on 32,000 specialised dairy farms in the Netherlands (Agricultural Economics Research Institute 1996). The farms had on average, 53 cows and 31 hectares of land with an average milk production of 6954 kg per cow per year. Surplus cattle were sold as calves, heifers or fattening cattle. About 50,000 head of cattle were sold for live export annually.

According to the Dutch extension services the major routes through which an infectious agent can be introduced on to a farm are (Koole 1995):

- Contact with other dairy cows, for example with purchased cows or cows at cattle shows;
- Contact with other animal species that are potential carriers of the disease, for example sheep, goats, rats and dogs;
- Transmission by humans, for example visitors and veterinarians;
- Transmission by machinery, for example cattle trucks, manure spreaders and other tools;
- Transmission by foodstuffs or water, for example ditch water;
- Transmission by air.

Research was carried out to investigate the number and kind of contacts which, on average, Dutch dairy, pig and mixed farms have (Nielen and others 1996). When risky contacts, such as buying cattle and the visits of a veterinarian, were combined with less risky contacts such as the transport of feed and milk, and social human contacts, cattle farms had a median of 6·9 contacts per day. A survey of the Animal Health Service in the northern provinces of the Netherlands in 1995 showed that 55 per cent of the dairy farms had purchased cows in the preceding year (G. Benedictus, personal communication). Direct and lengthy animal contacts are the most important risk factors, followed by contacts with people or animal transport vehicles, animal products and transmission by feed, vermin or air (Wentink and others 1993, Koole 1995, Horst and others 1996). The most usual way in which bovine herpesvirus 1 (BHV-1) is transmitted between farms is by the introduction of latently infected animals on to a farm (Msolla and others 1981, Pastoret and others 1984). To introduce a closed farming system farmers need to be made aware of the risk of the introduction of infectious diseases on to the farm. Farmers will be more likely to implement a closed farming system when they are aware of the economic value of such a system. However, the economic value of maintaining stable animal health and a closed farming system has not been quantified.

The present study explores the economic value of the adaptations in management required to introduce a closed system on to dairy farms to prevent the introduction of diseases and to improve the health of animals on the farm. According to the advice of the extension services, the Animal Health Service and National Reference Centre for Livestock Production, a closed farming system may prevent the introduction of, for example, BHV-1, bovine virus diarrhoea virus, leptospirosis, paratuberculosis and salmonella on to a farm, and can be a good starting point for the eradication of these infectious diseases. Further study will be necessary to reveal the epidemiological characteristics of a closed farming system. This study evaluates the advice of the extension services on the economic characteristics of a closed farming system.

Materials and methods

An exploratory study was carried out to investigate the technical and economic results on open and closed dairy farms. The data were derived from an accounting system for Dutch dairy farms (DELAR) and cover a period of two years. DELAR is used on approximately 2500 farms and provides each farmer with information on average animal performance (milk production and cattle credits), land use (forage production and some other crops), fodder consumption (concentrates, forage and milk products) and remaining costs for fertilisers and contract work. The dataset contained data from 1485 farms for 1991/92 and 1992/93.

The farms were grouped by several variables present in the accounting system, namely the income from, or the costs of, sharing pasture, the numbers of animals purchased, and the numbers of animals reared for or on other farms. If a farm did not share pasture, rear animals for or on other farms, or purchase cattle, it was defined as a 'closed' farm; otherwise the farm was defined as 'open'.

To gain an insight into which variables accounted for the differences between the open and closed farms, multivariate analyses (discriminant analysis and regression analysis) were carried out. Discriminant analysis is a statistical technique for studying the

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TABLE 1: Mean (sd) values of the variables according to when a farm was defined as 'open' on 1129 open farms

	Mean (sd)	Min	Max
Cost of sharing pasture (£)*†	559·3 (1242·9)	0	20,240
Returns from sharing pasture (£)†	168·1 (741·2)	0	10,714
Number of cattle purchased	2·9 (4·4)	0	33·0
Number of animals shared elsewhere	4·4 (7·7)	0	57·2
Number of animals shared on the farm	0·1 (1·1)	0	18·2

* £1 = Dfl 2.80 (November 1996)
† Costs or returns are figures derived from the accounting system. A farmer incurred costs for having cattle grazed on other farms or was paid when cattle from someone else were grazed on his farm

differences between two or more groups of objects with respect to several variables, simultaneously (Klecka 1980). In this study, the farms (data cases) were divided into two groups (open and closed) according to several discriminating variables, for example purchase of cattle and sharing pasture for cattle. Discriminant analysis with the CANDISC procedure (SAS 1988) results in a discriminant function consisting of independent variables (Klecka 1980). The variables of this function influence the difference between the open and closed farms. The discriminant analysis was carried out on half the farms in the dataset. The other farms were used for the linear regression analysis with the REG procedure (SAS 1988) to predict the farms' economic results. A forward stepwise selection procedure at P<0·10 was used to select the variables for the model. The variables which were highly correlated (r>0·50) were excluded from the model. Only variables which remained significant at P<0·05 were included in the final model.

Results

Grouping variables

In the two-year period, 356 (24 per cent) of the 1485 farms did not buy cattle or share pasture. The remaining 1129 farms could not be called closed in these respects in either one or both years. Table 1 provides the average figures for the criteria according to when a farm was defined as open.

On average, only small numbers of animals were moved per farm per year (Table 1). A farm on average purchased 2·9 cows per year and shared 4·4 cows elsewhere. The low mean value (2·9) and standard deviation (4·4) and the high maximum value (33·0) for the purchase of cattle show that only a few of the open farms purchased a large number of cattle.

Discriminant analysis

Table 2 shows all variables of the discriminant analysis which significantly influenced (P<0·05) the difference between the open and closed farms. The higher the value of the coefficient, the more strongly the variable influenced the differences between the open and closed farms. A variable with a positive value indicates that the variable was higher on the open farms. A variable with a negative value was higher on the closed farms. The most important variable was the 'percentage of replacements of cows' (0·80) which was higher on the open farms. The next most important variable was 'births per 100 cows' (–0·58) which was higher on the closed farms. The value of the coefficients of the other variables were smaller, indicating that the impact of these variables on the difference between the open and closed farms was smaller. Almost at the bottom of the list was 'veterinary costs per cow', a variable with a relatively low impact on the difference (0·07) which was nevertheless significantly higher on the open farms.

Regression analysis

A regression analysis was carried out to predict the net profit per 100 kg of milk. A stepwise selection procedure on 741 of the farms in the dataset resulted in the linear regression model without intercept (r^2 = 0·99; root MSE = 239·7; P<0·05) shown in Table 3.

TABLE 2: Variables which significantly influenced (P<0·05) the difference between open and closed farms and their contribution to the difference

Variables	Contribution to the difference between open and closed farms
Percentage of replacements of cows	0·80
Number of births/100 cows	–0·58
Fat content in milk	–0·36
Net profit/hectare	0·29
Percentage of youngstock	–0·27
Phosphorus/hectare (kg)	–0·25
Average age at first calving	0·24
Nitrogen/hectare (kg)	–0·23
Roughage costs/cow	0·20
Number of dead cows	–0·20
Irrigation of pasture	–0·19
Automatic concentrate feeding/forage mixer	–0·10
Veterinary costs/cow	0·07
Concentrate costs/cow	0·01

The high value of r^2 did not have any meaning in a model without intercept. The price of milk was approximately £0.27 per kg and the average milk production per cow used in the calculations was 7500 kg. Open farms had a negative influence of almost £0.31 per 100 kg milk on net profit, or approximately £25 per cow per year or 5 per cent of the typical net return to labour and management. Furthermore, the protein and fat content of the milk, and the breed of cow had a positive influence on the net profit per 100 kg of milk. The number of cows per hectare, the use of automatic concentrate feeding or a forage mixer, the number of dead calves and cows, and the number of births per 100 cows all had a negative influence on the net profit per 100 kg of milk. To place the figures in perspective, some costs are provided. The price of a milking cow was, on average, £500 and the price of a hectare of grassland was, on average, £13,500.

Discussion

Farms which purchased cattle and/or shared pasture (open farms) differed in their technical results from farms which did not (closed farms). The results of the discriminant analysis showed that the closed farms had a higher birth rate per 100 dairy cows, a lower average age at first calving and lower costs for veterinary services. A linear regression analysis was carried out to investigate the influence of the farming system on economic performance. The half of the dataset not used in the discriminant analysis was used for the regression analysis. Several variables found in the discriminant analysis influenced economic farm performance considerably (Table 3). An open farm was found to have a negative influence of £0.31 per 100 kg of milk on net profit, or approximately £25 per cow per year or 5 per cent of the typical net return on labour and management of a farmer.

TABLE 3: Regression on net profit (in £) per 100 kg of milk

Independent variables*	Dependent variable: net profit per 100 kg of milk
Protein content in milk	4·76
Fat content in milk	3·30
Number of cows per hectare	–2·00
Dutch red and white or RHF breed compared with HF	0·39
'Open' farm	–0·31
Automatic concentrate feeding/forage mixer	–0·27
Number of dead cows	–0·21
Number of calves dying within 14 days	–0·05
Number of births/100 cows	–0·03
Hectares of pasture	–0·03

*All variables in the model are significant at P<0·05
RHF Red Holstein Freisian, HF Holstein Freisian

The DELAR program is a tool for accounting dairy farm performance. As a result, the available datasets limited the possibilities of the analyses. The division into open and closed farms was based only on cattle purchases and the sharing of pasture. No data were available on other types of contact, such as visiting cattle shows, natural service, visitors to the farm, and whether other animal species such as pigs, sheep and beef cattle were present, was not known. Moreover, the grouping into open and closed was based only on two years and it was not known whether the farmer did or did not purchase cattle or share pasture in the preceding years. Causal relationships between a closed dairy farming system, animal health, and farm results could also not be derived from these data, because no data on management and animal health were available. However, the negative effect on the net profit per 100 kg of milk of an open with respect to a closed farming system justifies further research in this respect.

To gain a better understanding of the influence of farming systems on the introduction of diseases, animal health and farm results, apart from the role of management, a supplementary study will be carried out. This study will concentrate on animal health and management in relation to a more or less closed farming system and the costs and benefits of such a system. The farms used in the study will all have a known disease status for BHV-1. Data on the farming system, the degree to which a farm is closed, and the management by the farmer, especially with respect to diseases, will be collected by means of a questionnaire. The objective of the study will be to see whether farms which differ in their serological status for BHV-1 differ in their risk factors for the introduction of diseases, in their management of animal health, and in their economic results.

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Effect of hoof characteristics on the propensity of cattle to slip

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Bovine hooves were assessed for their linear and volumetric characteristics and ranked in sets of four for hoof volume. An artificial cow was constructed with the hooves set into metal cylinders underneath a platform containing a known weight. The device was connected via a strain gauge to a pulling handle operated by two people, and the horizontal force required to move each set of hooves was determined three times. The coefficient of friction, calculated as the horizontal force divided by the fixed vertical force, was positively correlated with hoof volume. The same exercise was repeated with the hooves ranked for toe angle, and the hooves with steep toe angles had a lower coefficient of friction than the hooves with shallow toe angles. However, since both hoof volume and toe angle were related to toe length, the relationship between friction and toe angle was believed to derive from the larger size of claws with shallow toe angles. The results indicate that young cattle that have small claws with smooth surfaces and steep toe angles are more likely to slip.

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SINCE the introduction of cubicle housing for dairy cows in the 1960s, many concrete floors have become smooth as a result of the frequent scraping away of faeces and urine and heavy cow traffic. As a result slipping is a regular cause of injury to cows (Mitchell 1974), and they tend to adopt an unnatural posture while walking, with the head orientated towards the floor and the swinging movement of the leg abbreviated (Phillips 1990). A cow slips when the vertical force between the hoof and the floor is insufficient to counteract the horizontal force induced by the leg during walking. The resistance to the horizontal motion of the hoof on the floor is termed friction. A cow is most likely to slip at the beginning or end of its stride, when the vertical loading on the leg is diminished owing to the redistribution of the cow's weight to the other legs (Phillips 1993). Most research to counteract this problem has been directed at improving the frictional properties of the floor, either by cutting grooves in the surface (Albutt and others 1990), or by covering the floor with a synthetic resin into which an aggregate is embedded (Morris and Phillips 1994). Both provide small vertical surfaces against which the hoof can push, but the techniques are expensive and not entirely successful. However, it may be possible to improve the hoof's frictional properties by breeding cows with an optimum shape and size of hoof. The size, toe angle, dorsal border length and heel height of hooves all have moderate to high heritabilities (Hahn and others 1977, McDaniel and others 1984, Smit and others 1986, Andersen and others 1991). The size, toe angle and toe length of hooves can be measured in the live animal with a high degree of repeatability

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