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No. 2004-2 – August 2004

Working Paper Series in

Agricultural and Resource Economics

ISSN 1442 1909

http://www.une.edu.au/febl/EconStud/wps.htm

 ISBN 1 86389 8808

The Distribution of Gains from Cattle Development in a Multi-Stage Production System: The Case of the Bali Beef Industry *

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Abstract

Beef production in Bali is dominated by small-holders, like the majority of Indonesian agriculture. A number of different policies have been implemented to enhance development of this and other parts of the Bali beef industry. Knowledge about the returns from these options for the development of the cattle and beef industry, and their distribution among producers, consumers and others, would better inform policy decision making. This paper examines the benefits from cattle development in a multi-stage production representation of the Bali beef industry using equilibrium displacement modelling (EDM). For a 1 per cent exogenous shift in the relevant market, improved productivity of Bali cattle production has the largest total benefits (Rp 3.02 billion, about A$ 0.6 million), over a time horizon of 2-3 years. Bali cattle producers receive a substantial share (35 to 71 per cent) of the total returns from any cost reduction or improved efficiency scenario.

Key Words: **:** equilibrium displacement model; research evaluation; Bali; cattle and beef industry; economic analysis.

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* This is a revision of a paper presented at the 47th Annual Conference of the Australian Agricultural and Resource Economics Society, Fremantle, Australia, 11–14 February 2003. The helpful comments of AARES conference participants are much appreciated.

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INTRODUCTION

Changes in food consumption patterns in Indonesia resulting from increases in income, urbanisation and population growth have led to changes in Indonesian agricultural production and trade. There have been some attempts to improve productive capacity, but in many sectors such as beef cattle, production has not been able to keep pace with the increase in consumption. Small-holder farms using basic technology with relatively low levels of productivity dominate beef production, just like the majority of Indonesian agriculture. The result has been increased imports of live cattle and beef products.

In an attempt to improve the productivity of the traditional beef sector, the Indonesian government has set out a wide range of policies to enhance development. The most notable development program is the Beef Nucleus-Estate Smallholder (Beef NES) scheme, implemented in 1980. This scheme was aimed to provide smallscale farmers with access to capital and technology. The government has also encouraged the involvement of the private sector in the feedlot system using imported feeder cattle. However, the impact of the financial crisis in mid 1997 made imports more expensive and highlighted the problem of a heavy reliance on imports. Government policy since the financial crisis has focussed on making the best use of local resources.

Two more recent schemes in cattle development are the Food Safety Credit (*Kredit Ketahanan Pangan*/KKP) and the Food Safety Project (*Proyek Ketahanan Pangan*/PKP). The broad objective of the schemes is to increase small-holders' income by improving their productivity. In addition, the schemes are expected to provide higher quality beef through the implementation of improved technology such as better nutrition, artificial breeding technology and better management (see Ambarawati *et al*. 2002 for details).

The island of Bali is one of the main cattle producing areas for Indonesia. An indigenous Indonesian cattle breed, Bali cattle (*Bos sondaicus*), is kept pure on the island of Bali despite the wide dispersion of this breed throughout the country. This policy was enacted to maintain and improve domestic animal genetic resources. Bali cattle are known for their desirable traits, such as good adaptation to arid conditions, high fertility and high efficiency in producing lean beef (Masudana 1990). There are no cattle imported into Bali due to the absolute protection of Bali cattle. However, cattle from Bali are highly demanded outside

Bali, especially in Jakarta. DPPB (2000) noted that about 60 per cent of cattle traded in Bali are sent off the island. The island is also known for its extensive tourist sector. Frozen and chilled beef are imported to fulfil the tourist demand. This imported beef competes with the local beef in the tourist sector.

As well as the national policies mentioned above (Beef NES, KKP and PKP), the Bali government has put in place additional policies for developing this indigenous cattle breed to increase inter-island cattle trade and to improve beef quality to compete with imported beef. These include feed supplementation programs, artificial insemination programs and subsidised credit (although adding value to livestock through marketing seems to be of little concern). Moreover, the implementation of local autonomy policies and budget self-reliance at the beginning of 2001 has encouraged the Bali government to develop local resources such as cattle.

Previous studies of the Bali cattle industry were mainly concerned with the physical productivity of the breed such as feed conversion and carcass weight, and there are very few policy evaluation analyses of the beef sector. Ambarawati *et al*. (2002) assessed the impact of cattle development schemes on farm performance in Bali, but did not include any links to the marketing sectors. Knowledge about the distribution of the returns from the development of the cattle industry, including marketing, informs decision making about the various policy options available.

The objective of this paper is to develop an economic model of the Bali beef industry to simulate various policies and other exogenous changes. The impact of these changes on various industry groups such as small-holders, processors, retailers and consumers, can be estimated in terms of their welfare changes.

THE BALI BEEF INDUSTRY

The Bali beef industry in this study refers to the geographical entity, Bali island (also the Province of Bali). The Bali beef industry involves multiple markets and marketing stages. Demand for beef in Bali comes from two different markets: the wet market and the higher end market, also known as the HRI (hotel, restaurant and institutional) market. Demand for fresh beef at the wet market comes from the local population, while fresh beef ,and frozen and chilled imported beef, are demanded to satisfy the star-rated hotels, selected supermarkets and catering companies. The beef going to the wet market is not as well graded as the beef supplied to the HRI market, and is perceived to be of lower quality. The wet market, which comprises some 80 per cent of the total beef demand in Bali, is fully supplied by Bali beef. On the other hand, the Bali HRI market is currently satisfied by both Bali beef and imported beef. Before the financial crisis in mid 1997, imported beef dominated beef supply to the HRI market and Bali beef accounted for only a small amount of the total beef demand. However, since the financial crisis Bali beef has increasingly been accepted to fulfil demand from the HRI market. Bali beef is now a substitute for imported beef in the HRI market.

Beef Production for the Wet Market

Beef processing for the wet market in Bali is undertaken by the public abattoirs. Retailers at the wet market cut the carcasses and sell to final consumers. Beef cuts at the wet market are not well graded as the consumers seem to be indifferent to beef quality. Carcass production from public abattoirs is derived solely from Bali cattle.

There is no specification of a production system for cattle in Bali for different purposes, but the weight of cattle sold for the wet market is usually above 300 kg. Cattle are usually grazed on public fields or maintained under a shed by small-scale farmers. Cattle are sometimes fed with feed supplementation such as rice bran. Heavier cattle are usually selected for the higher end market and for the inter-island trade.

Beef Production for the HRI Market

Bali beef production for the HRI market is a different process from the wet market production in terms of cattle selection, processing and marketing. Bali beef for the HRI market comes from carcass production from private slaughtering houses. The carcasses produced from private abattoirs are of perceived higher quality to meet retailers' demand. Retailers and packers at the HRI market cut and trim the carcasses and sell to the consumers. Beef cuts at the HRI market are graded to meet consumers' requirements.

Cattle are selected at the market by private abattoir operators to obtain the higher quality carcasses. This selection is mainly based on physical appearance and cattle weight. The average cattle weight for the HRI market is 375 kg. Some private slaughtering houses have their own cattle contracts with farmers so they can control their cattle weight and quality. While carcasses produced from private abattoirs are mainly directed to the HRI market, by-products and off-cuts of these carcasses are sold to the wet market. It is estimated that 20 per cent of total carcass production from private abattoirs are sent to the wet market. The main difference between private abattoirs and the public abattoirs is in the processing facilities. Private abattoir operations are more mechanised than public slaughtering houses to meet certain grading criteria.

Although Bali cattle are sold to different markets, there are no specific cattle producers for each market. All cattle traded come from the same small-holder producers without any product specification. Cattle are valued based on their liveweight with the same price per kilogram live weight.

A CONCEPTUAL MODEL OF THE BALI BEEF INDUSTRY

The Bali beef industry is disaggregated into a horizontal and vertical structure to examine the benefits of government policies and research that occurs in various industry sectors and markets, as well as the distribution of benefits among different industry groups. Horizontally, the market is segmented based on the type of beef demanded: wet market beef and HRI market beef. Vertically, beef production and marketing are disaggregated into cattle supply, processing, marketing and consumption. This segmentation enables separate analyses of various policies at different stages of marketing. Inputs other than the cattle input are treated as a general 'marketing input' in all sectors.

The demand for imported beef at the HRI market is included in this segmentation. The quantity of imported beef is treated as an endogenous variable in the model, but the price of imported beef is treated as an exogenous variable. As Indonesia is not a major player in beef imports in the world market, it is considered that the supply of imported beef is perfectly elastic. On the other hand, the demand for imported beef is assumed to be downward sloping.

The model also includes the rest of Indonesia (ROI) market in order to capture the impacts of inter-regional trade on Bali cattle production. It is believed that any changes in beef demand outside Bali will affect cattle production in Bali. The Bali geographical market and the ROI market are linked through the quantity of cattle traded and the cattle price. Any policy change occurring in the ROI market is treated as an exogenous shifter to Bali cattle production and allocation.[1]

Based on the industry structure reviewed above, the model of the Bali beef industry is specified in Figure 1. As shown in the figure, there are four production functions, represented by rectangles on the diagram. Each production function creates the demand and supply for a product represented by the ovals on the diagram. In each supply or demand schedule an exogenous shift may occur. The inclusion of the exogenous shifters in this model enables separate analyses of various policies at the farm level, processing stage and retail marketing. There are 13 factor or product markets involving 24 quantity and price variables. There are also two aggregated input and output index variables for the processing sector at private abattoirs. This gives 26 endogenous variables for the 26 equations and identities in the system. The definitions of all variables and parameters in the model are presented in Table 1. The detailed algebraic form of the structural model of the Bali beef industry is presented in the Appendix.

METHODOLOGY

This research is based on a synthetic model, often referred to as an Equilibrium Displacement Model (EDM). EDM has been frequently used in agricultural price and policy analysis (see for example Alston *et al*. 1995; Mullen *et al*. 1988,1989; Zhao *et al*. 1999). The EDM involves the application of comparative static analysis to a structural model involving unspecified functional forms. The main strength is that it allows quantitative assessments to be made of the impacts on endogenous variables of small changes in exogenous variables in situations where there are no resources available or the data are too unreliable to engage in econometric modelling (Piggott 1992). In the EDM approach, the market is disturbed by a change in the value of an exogenous variable and the impacts of the disturbance are approximated by functions that are linear in elasticities and proportional changes. These functions are obtained following total differentiation of the structural model and conversion to elasticities and proportional changes.

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[1] A larger version of the model is also available where the ROI sector is fully endogenous. However, given the relative sizes of the beef markets in the two geographic sectors, little extra information is provided by using this version.

The impact of a 1 per cent change in an exogenous variable (from productivity advances or quality improvements) is simulated. Changes in prices and quantities in all markets due to this exogenous shift are estimated and consequent changes in producer and consumer surpluses in the relevant markets are calculated. Comparisons of welfare changes among different scenarios are conducted.

DATA REQUIREMENTS

Operation of the EDM requires three different sets of information. Firstly, base price and quantity values are needed for all endogenous variables to portray the base equilibrium status of the system. Secondly, various elasticity values are needed. Finally, values all exogenous shifters are needed to quantify the impact of policy changes at different levels of marketing.

The availability of data on the Bali beef industry is very limited. The Central Bureau of Statistics of Indonesia (CBSI) and the Directorate General of Livestock Services (DGLS) provide annual data on beef production for all provinces in Indonesia, measured in kilotons carcass weight. However, there is no published information on final beef products such as the quantity of beef entering the wet and HRI markets respectively. Information on the quantities of carcass produced from public and private abattoirs is also lacking. Hence, assumptions are made on the proportion of carcasses produced at different abattoirs and beef produced for the wet and HRI markets based on the information provided by DGLS staff, Bali Regional Livestock Services staff and other industry agencies. Considerable effort has been made in this study to assemble a set of equilibrium quantities and prices at different stages. These include a survey of public and private abattoirs, hotels and restaurants in Bali to obtain the required information. A combination of published information and survey information has been used to estimate the data required at the different levels and market segments.

Price and quantity values used in this study are based on the year 2000, assuming that the beef market situation in Indonesia had returned to normal after the 1997 financial crisis. There was a sharp increase in imported beef into Indonesia, from 10.55 kt in 1999 to 26.96 kt in 2000. Beef imported into the Bali HRI market increased from 165 tonnes in 1999 to 300 tonnes in 2000. This is a good indication that the economy is gradually recovering from the financial crisis. Values of base equilibrium quantities and prices for all endogenous variables including the cost and revenue shares for all sectors are presented in Table 2.

Market parameters required in the model include the elasticity values of various beef demand and input supplies, input substitution and product transformation. Parameter values are selected on the basis of economic theory, past studies of the beef industry and intuition. The values of market parameters are presented in Table 3.

There are seven exogenous shift variables in this study allowing different policy and R&D scenarios to be examined. Improved productivity of cattle production and increased efficiencies in processing and marketing sectors are modelled as reducing the cost of production in the relevant sectors. This can be seen as an outward or downward supply shift. Quality-enhancing research for Bali beef in the HRI market and policy changes in the ROI market are modelled as an outward shift in demand. Equal 1 per cent vertical shifts in the relevant supply and demand curves are assumed for all seven scenarios. These are explained in Table 4.

RETURNS FROM ALTERNATIVE CATTLE DEVELOPMENT POLICIES

Having specified initial prices and quantities and market elasticities, the resulting percentage changes in all prices and quantities are calculated by simulating the model described in the Appendix for each of the scenarios described in Table 4. Using the changes in prices and quantities, the changes in economic surplus for the various groups are calculated. The results of the total welfare changes and their distribution among industry groups such as cattle producers, processors, retailers and consumers for each of the seven scenarios are presented in Table 5.

Some initial explanation of the results should be noted before any comparison is undertaken. This study relates to equal 1 per cent exogenous shifts in the relevant supply and demand curves but the costs required to bring about 1 per cent shift is not addressed here. Therefore, the monetary benefits from alternative scenarios in Table 5 are only comparable under the assumption of equal investment efficiency, in the sense that the investment costs of the 1 per cent shifts in all sectors are the same. This indeed is unlikely to be true in reality. Issues regarding the efficiency of investments have been discussed by a number of authors include Lemieux and Wohlgenant (1989), Scobie *et al*. (1991) and Zhao (1999). Zhao (1999) also pointed out that the distribution of the total benefits among industry groups is independent of the size of the initial shift, even if the same amount of investments at different points of the industry may cause demand and supply shifts of different magnitudes, and although the actual returns in monetary terms are dependent on the magnitudes of the initial shifts. Accordingly, it is always worthwhile to compare shares of benefits among alternative investment scenarios without knowledge of the efficiency of research investment.

The results indicate that the size of total economic surplus changes is determined largely by the total value of the sector where the exogenous shift occurs. As can be seen from Table 5, for the same 1 per cent exogenous shift in the relevant market, improved productivity of Bali cattle production resulting from government intervention (Scenario 1) has the largest total annual benefits (Rp 3.02 billion, about A$ 0.60 million). This is about 1 per cent of the total annual value of Rp 301.83 billion at the farm gate. Policy changes from the ROI market (Scenario 7) amounts to Rp 1.71 billion (A$ 0.34 million) but there are much smaller returns for quality-enhancing research in the HRI market (Rp 0.46 billion). The total benefits from improved efficiencies in the processing and marketing sectors (Scenario 2 – 5) are all very small, ranging from Rp 0.03 billion to Rp 0.20 billion. These small returns are due to the small value added to the beef products in those sectors and the highly elastic nature of the supply of other inputs.

In terms of the distribution of returns among various industry groups, Bali cattle producers receive substantial benefits (35 per cent to 71 per cent of total returns) from productivity-enhancing or quality-enhancing R&D scenarios. This is because cattle production has the largest value within the industry groups. On the other hand, Bali beef consumers in both the wet and HRI markets gain much less surplus than cattle farmers due to the lesser gross revenue in those markets. The ROI consumers only receive gains from the cost reduction in Bali cattle production but the benefits are much bigger than for beef consumers in Bali. This is because the total value of cattle shipped outside Bali is much bigger than the beef value at the final stage in Bali. However, any improved efficiencies at the marketing level in Bali (Scenario 2 –5) result in a welfare loss to the ROI consumers as less cattle are traded to the ROI market.

Processors and retailers receive insignificant shares of welfare benefits from productivity-enhancing and quality-enhancing R&D scenarios, ranging from 0.17 per cent to 11.50 per cent of the total benefits. These small portions are due to the assumption of an elastic supply curve for marketing inputs (with an elasticity value of 1.5). These results are in line with similar studies in the beef industry such as in Wohlgenant (1993) and Zhao (1999). The issue of the magnitude of marketing supply elasticity is discussed in Zhao *et al*. (2002).

The majority of the results from these simulations also reveal that the quantity of imported beef entering the HRI market is reduced by 0.01 per cent to 0.09 per cent for a 1 per cent cost reduction in any of the marketing stages. This implies that government policy aimed at reducing beef imports can be met by increasing efficiencies in the relevant sector, such as reducing the cost of Bali cattle production, resulting in more Bali beef entering the HRI market.

These results can be ranked according to various criteria. Here we rank them according to both absolute returns to farmers and the percentage share of total returns going to farmers (Table 6). Farmers are the focal point because the stated objectives of the cattle development policies are to enhance the livelihoods of the small-holder cattle producers. The ranking in the first column is limited under the assumption of equal efficiency among the seven scenarios. The ranking in the second column is always right despite unavailable information on the costs involved in bringing the initial 1 per cent shift. Scenarios 1 and 7 dominate both rankings. Thus decreasing the cost of producing cattle or generating greater demand from the inter-island market, are the two main ways that Bali cattle producers can benefit from industry development.

Another way of looking at these results (Zhao *et al.* 2000) is to calculate the percentage shifts required in the other market sectors to provide the same return to cattle producers (Rp1.93 billion, about A$ 0.39 million) as from Scenario 1 (Table 7). Scenario 7 requires a greater shift than Scenario 1 but of the same broad order of magnitude, however the other Scenarios require shifts of between 10 and 193 times larger, to provide Rp 1.93 billion to farmers.

SUMMARY AND CONCLUSIONS

The Bali government has put in place policies for developing the Bali cattle breed to increase the inter-island live cattle trade and to improve Bali beef quality to compete with imported beef in the tourist sector in Bali. Information on the benefits from development of the cattle industry is limited and therefore evaluation of the various policies is required to guide future policy development. In this paper, an economic model of the Bali beef industry was developed to simulate various policies and exogenous changes. The impacts of these changes on various industry groups were examined in terms of their welfare changes over a medium-term period of adjustment, say 2-3 years.

For a 1 per cent exogenous shift in the relevant market, improved productivity of Bali cattle production has the largest total benefits (Rp 3.02 billion, about A$ 0.6 million). Increased demand from the ROI market amounts to Rp 1.71 billion (A$ 0.34 million). The total benefits from improved efficiencies in the processing and marketing sectors are very small, ranging from Rp 0.03 billion to Rp 0.20 billion. In terms of the distribution of returns among various industry groups, Bali cattle producers receive substantial benefits (35 to 71 per cent of total returns) from any cost reduction or improved efficiency scenarios. Bali beef consumers in both the wet and HRI markets gain much less surplus than cattle farmers.

The model seems appropriate for examining other types of R&D and policy scenarios to those described above. For example, estimates of the cost savings from particular types of policies (see Ambarawati *et al.* 2002) can be used as input rather than hypothetical 1 per cent shifts. However more research is needed in several areas. In particular, since the data are quite scarce and there is much uncertainty about some of the assumptions made, formal sensitivity analyses are required to ensure that the generated results are not highly dependent on particular assumed values.

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Figure 1. The structural model of the Bali beef industry

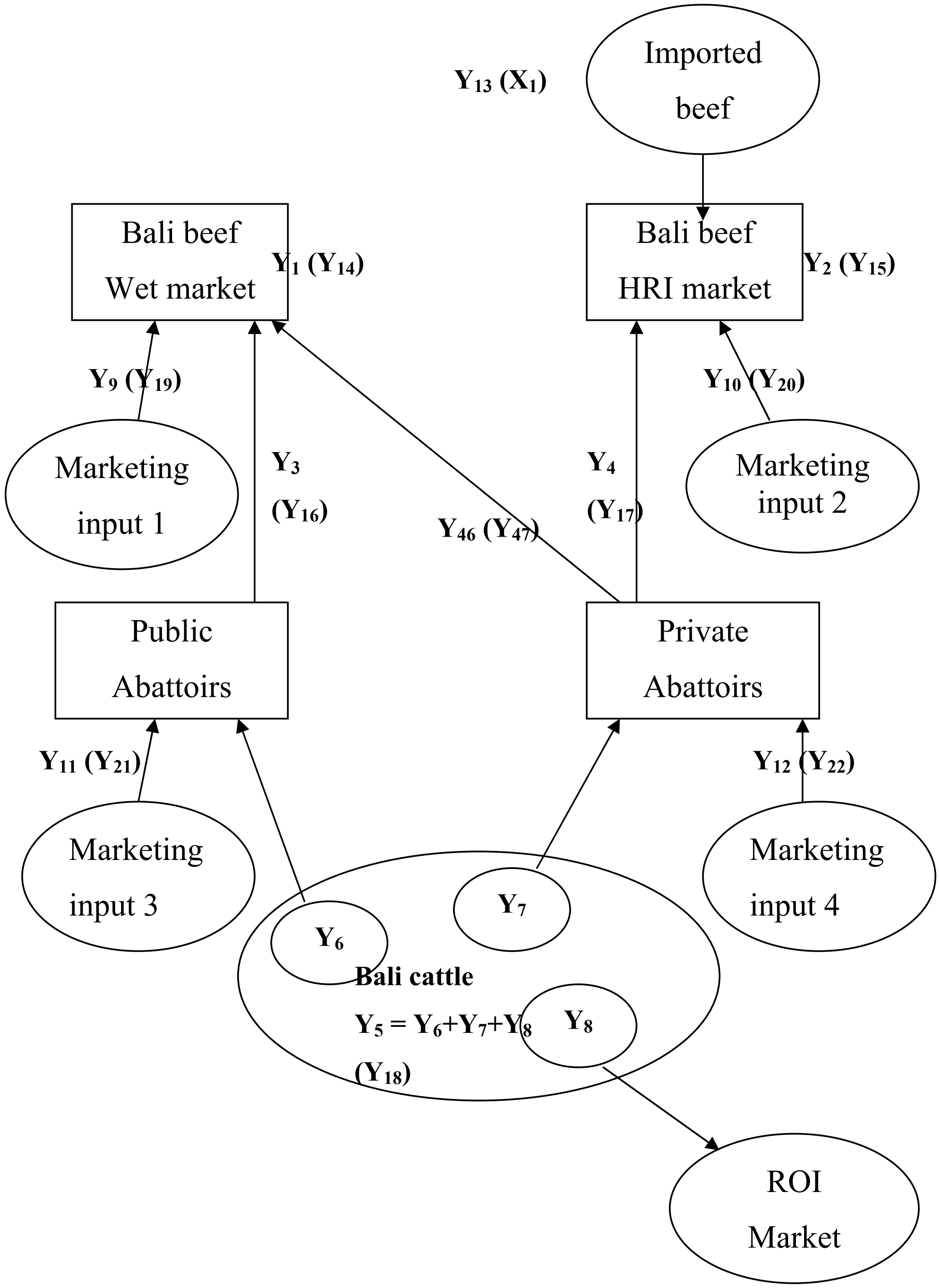

Table 1. Definitions of variables and parameters in the model

Endogenous variables

Y_1	quantity of Bali beef for the wet market.
Y_2	quantity of Bali beef for the HRI market.
Y_3	quantity of carcasses from public abattoirs for the wet market.
Y_4	quantity of carcasses from private abattoirs for the HRI market.
Y_5	quantity of Bali cattle total.
Y_6	quantity of Bali cattle for public abattoirs.
Y_7	quantity of Bali cattle for private abattoirs.
Y_8	quantity of Bali cattle traded to the rest of Indonesia (ROI) market.
Y_9	quantity of marketing input 1.
Y_{10}	quantity of marketing input 2.
Y_{11}	quantity of marketing input 3.
Y_{12}	quantity of marketing input 4.
Y_{13}	quantity of imported beef to the HRI market.
Y_{14}	price of Bali beef at the wet market.
Y_{15}	price of Bali beef at the HRI market.
Y_{16}	price of carcasses at public abattoirs.
Y_{17}	price of carcasses at private abattoirs.
Y_{18}	price of Bali cattle.
Y_{19}	price of marketing input 1.
Y_{20}	price of marketing input 2.
Y_{21}	price of marketing input 3.
Y_{22}	price of marketing input 4.
Y_{46}	quantity of carcasses from private abattoirs for the wet market.
Y_{47}	price of carcass from private abattoirs for the wet market.
Z_{BI}	aggregated input index for carcass production at private abattoirs.
Z_{BO}	aggregated output index for carcass production at private abattoirs.

Exogenous variables

X_1	price of imported beef.
N_{yi}	demand shifter shifting up demand curve of Y_i vertically due to quality improvement that increase the demand in Y_i, where $Y_i = Y_2, Y_8$.
EN_{yi}	amount of shift N_{yi} as a percentage of price Y_i, where $Y_i = Y_2, Y_8$.
T_{yi}	**s**upply shifters shifting down supply curve of Y_i vertically due to cost reduction in production of Y_i, where $Y_i = Y_5, Y_9, Y_{10}, Y_{11}, Y_{12}$.
ET_{yi}	amount of shift T_{yi} as a percentage of price Y_i, where $Y_i = Y_5, Y_9, Y_{10}, Y_{11}, Y_{12}$.

Parameters

$\eta_{(x,y)}$	Elasticity of demand for commodity x with respect to variable y.
$\varepsilon_{(x,y)}$	Elasticity of supply of commodity x with respect to variable y.
$\sigma_{(x,y)}$	Allen's elasticity of input substitution between input x and input y.
$\tau_{(x,y)}$	Allen's elasticity of product transformation between output x and output y.
s_i	cost share of input x (x = y_3, y_4, y_6, y_7, y_8, y_9, y_{10}, y_{11}, y_{12}, y_{46}) where $\sum_{i=3,9,46} s_{yi} = 1$, $\sum_{i=6,11} s_{yi} = 1$, $\sum_{i=4,10} s_{yi} = 1$, $\sum_{i=7,12} s_{yi} = 1$.
γ_y	Revenue share of output y (y = y_4,y_{46}) where $\sum_{i=4,46} \gamma_{yi} = 1$.
ρ_x	Quantity shares of x (x= y_6, y_7, y_8), where $\sum_{i=6,7,8} \rho_{yi} = 1$.

Table 2. Values of base quantities and prices, cost and revenue shares

Stage of Marketing	Wet market	HRI Market
Final Beef Products (in *k*t & Rp/kg)	$Y_1 = 4.7$ $Y_{14} = 27500$ TV = 129.25b Marketing cost shares: $s_{y3} = 0.92$ $s_{y46} = 0.06$ $s_{y9} = 0.02$	$Y_2 = 1.18$ $Y_{15} = 39000$ TV = 46.02b Marketing cost shares: $s_{y4} = 0.80$ $s_{y10} = 0.20$ Import demand: $Y_{13} = 0.3$ $X_1 = 58000$ TV = 17.4b
Carcass Production (in *k*t & Rp/kg, carcass weight)	$Y_3 = 5.5$ $Y_{16} = 21565$ TV = 118.61b Public abattoir cost shares: $s_{y6} = 0.83$ $s_{y11} = 0.17$	$Y_4 = 1.47$ $Y_{17} = 25000$ $Y_{46} = 0.37$ $Y_{47} = 20000$ TV = 44.15b Private abattoir cost shares: $s_{y7} = 0.75$ $s_{y12} = 0.25$ Private abattoir revenue shares: $\gamma_{y4} = 0.83$ $\gamma_{y46} = 0.17$
Live cattle (in *k*t & Rp/kg, liveweight)	$Y_6 = 10.58$ $Y_{18} = 9334$ TV = 98.75b $Y_8 = 18.23$ $Y_{18} = 9334$ TV = 170.16b Production shares of Bali cattle to all markets: $\rho_{y6} = 0.33$, $\rho_{y7} = 0.11$, $\rho_{y8} = 0.56$	$Y_7 = 3.54$ $Y_{18} = 9334$ TV = 33.04b

Source: CBSI (2000); DPPB (2000)

Table 3. Elasticity and parameter values for the base run

Beef demand elasticities	**Input substitution elasticities**
$\eta_{(y1,y14)} = -1.1$ $\eta_{(y2,y15)} = -0.90$	***Marketing sector***
$\eta_{(y13,y15)} = 0.3$ $\eta_{(y13,x1)} = -2$	$\sigma_{(y3,y9)} = 0.1$ $\sigma_{(y3,y46)} = 0.05$
$\eta_{(y2,x1)} = 0.11$ $\eta_{(y8,y18)} = -1.0$	$\sigma_{(y9,y46)} = 0.1$ $\sigma_{(Y4,Y10)} = 0.1$
Cattle supply elasticities	***Processing sector***
$\varepsilon_{(y5,y18)} = 0.5$	$\sigma_{(y6,y11)} = 0.1$
	$\sigma_{(y7,y12)} = 0.1$
Marketing input supply elasticities	
$\varepsilon_{(y9,y19)} = 1.5$ $\varepsilon_{(y10,y20)} = 1.5$	**Product transformation elasticities**
$\varepsilon_{(y11,y21)} = 1.5$ $\varepsilon_{(y12,y22)} = 1.5$	$\tau_{(y4,y46)} = -0.05$

Source: Mullen *et al*. (1988); Mullen *et al*. (1989); Zhao (1999)

Table 4. Various scenarios for exogenous shift variables

Scenario 1:	Bali cattle production research. ET_{y5} = -0.01, the rest of $ET_{(.)}$ = 0 and $EN_{(.)}$ = 0. Cost reduction in Bali cattle production resulting from improved productivity encouraged by the Bali government using cattle development policies.
Scenario 2:	Processing research at public abattoirs. ET_{y11} = -0.01, the rest of $ET_{(.)}$ = 0 and $EN_{(.)}$ = 0. Reduction in processing cost in public abattoirs resulting from new technologies and improved management.
Scenario 3:	Processing research at private abattoirs. ET_{y12} = -0.01, the rest of $ET_{(.)}$ = 0 and $EN_{(.)}$ = 0. Reduction in processing cost in private abattoirs resulting from new technologies and improved management.
Scenario 4:	Marketing research at the wet market. ET_{y9} = -0.01, the rest of $ET_{(.)}$ = 0 and $EN_{(.)}$ = 0. Cost reduction in the wet market resulting from new technologies and improved management.
Scenario 5:	Marketing research for the HRI market. ET_{y10} = -0.01, the rest of $ET_{(.)}$ = 0 and $EN_{(.)}$ = 0. Cost reduction in the HRI market due to improved technologies and management.
Scenario 6:	Quality-enhancing research of Bali beef for HRI market. EN_{y2} = 0.01, the rest of $ET_{(.)}$ = 0 and $EN_{(.)}$ = 0. Increase in the willingness to pay by beef consumers in the HRI market resulting from improved Bali beef quality.
Scenario 7:	Policy changes in the ROI market. EN_{y8} = 0.01, the rest of $ET_{(.)}$ = 0 and $EN_{(.)}$ = 0. Increase in the willingness to pay by beef consumers at the ROI market resulting from policy changes such as guaranteed quality.

Table 5. Economic surplus changes (Rp billion) and percentage shares of total surplus to various industry groups from different scenarios in the Bali beef industry

Industry Group	Scenario 1 Improved productivity in cattle production		Scenario 2 Increased efficiency in public abattoirs		Scenario 3 Increased efficiency in private abattoirs	
	Rp b.	%	Rp	%	Rp	%
Bali cattle producers	1.93	63.90	0.09	45.00	0.042	39.18
Public abattoirs	0.030	0.99	0.023	11.50	0.003	2.73
Private abattoirs	0.014	0.46	0.003	1.50	0.011	10.00
Wet market retailers	0.005	0.17	0.002	1.50	0.001	0.90
HRI market retailers	0.011	0.36	0.002	1.00	0.004	3.64
Sub total Producer surplus	**1.99**	**65.89**	**0.12**	**60**	**0.061**	**55.45**
Wet market consumers	0.31	10.26	0.11	55	0.032	29.09
HRI market consumers	0.11	3.64	0.02	10	0.042	38.18
ROI market consumers	0.61	20.20	-0.05	-25	-0.025	-22.82
Sub total Consumer surplus	**1.03**	**34.11**	**0.08**	**40**	**0.049**	**44.55**
Total surplus	**3.02**	**100**	**0.20**	**100**	**0.11**	**100**

Table 5. Economic surplus changes (Rp billion) and percentage shares of total surplus to various industry groups from different scenarios in the Bali beef industry (cont.)

Industry Group	Scenario 4 Increased efficiency in the wet market		Scenario 5 Increased efficiency in the HRI market	
	Rp b.	%	Rp	%
Bali cattle producers	0.013	43.33	0.032	35.56
Public abattoirs	0.002	6.67	0.002	2.22
Private abattoirs	0.001	3.33	0.004	4.44
Wet market retailers	0.002	6.67	0.001	1.11
HRI market retailers	0.00	0	0.01	11.11
Sub total Producer surplus	**0.018**	**60.00**	**0.049**	**54.44**
Wet market consumers	0.018	60.00	0.018	20.00
HRI market consumers	0.002	6.67	0.041	45.56
ROI market consumers	-0.008	-25.67	-0.018	-20.00
Sub total Consumer surplus	**0.012**	**40.00**	**0.041**	**45.56**
Total surplus	**0.03**	**100**	**0.09**	**100**

Table 5. Economic surplus changes (Rp billion) and percentage shares of total surplus to various industry groups from different scenarios in the Bali beef industry (cont.)

Industry Group	Scenario 6 Quality improvement of Bali beef for HRI market		Scenario 7 Policy changes in the ROI market	
	Rp b.	%	Rp	%
Bali cattle producers	0.19	41.30	1.22	71.35
Public abattoirs	0.012	2.61	-0.033	-1.93
Private abattoirs	0.027	5.87	-0.015	-0.87
Wet market retailers	0.002	0.44	-0.005	-0.29
HRI market retailers	0.028	6.09	-0.012	-0.70
Sub total Producer surplus	**0.26**	**56.52**	**1.17**	**68.42**
Wet market consumers	0.11	28.08	-0.35	-20.47
HRI market consumers	0.20	47.52	-0.12	-7.02
ROI market consumers	-0.11	-25.92	1.01	60.23
Sub total Consumer surplus	**0.20**	**49.68**	**0.54**	**31.58**
Total surplus	**0.46**	**100**	**1.71**	**100**

Table 6. Preferences to farmers among the alternative investment scenarios

Rank	In terms of absolute benefits in rupiah (Rp b)	In terms of % share of total benefits (%)
1	S. 1 (1.93)	S. 7 (71.35)
2	S. 7 (1.22)	S. 1 (63.90)
3	S. 6 (0.19)	S. 4 (43.33)
4	S. 2 (0.09)	S. 2 (45.00)
5	S. 3 (0.04)	S. 3 (38.18)
6	S. 5 (0.03)	S. 6 (41.30)
7	S. 4 (0.01)	S. 5 (35.56)

Table 7. Percentage shifts required to generate the same benefits to farmers as from Scenario 1

	Scenario 1 Improved productivity in cattle production	Scenario 2 Increased efficiency in public abattoirs	Scenario 3 Increased efficiency in private abattoirs	Scenario 4 Increased efficiency in the wet market
Returns to Farmers (Rp billion)	1.93	1.93	1.93	1.93
Initial % shifts required (%)	1.00	21.44	48.25	193
	Scenario 5 Increased efficiency in the HRI market	Scenario 6 Quality improvement of Bali beef for HRI market	Scenario 7 Policy changes in the ROI market	
Returns to Farmers (Rp billion)	1.93	1.93	1.93	
Initial % shifts required (%)	64.33	10.16	1.58	

Appendix. Model specification of the Bali beef industry

Demand for Bali beef in the wet market:

(1) $Y_{14}= a(Y_1, N_{y1})$

Supply function of Bali beef to the wet market (market clearing condition):

(2) $Y_{14}=c(Y_{16}, Y_{19}, Y_{47})$

This equation expresses the long-run equilibrium condition that output price equals average per unit cost c(.)

When the production function shows constant return to scale, the industry total cost function can be written as:

$C_{Y1}=Y_1*c_{Y1}(Y_{16}, Y_{19}, Y_{47})$

C_{Y1} is the total cost of producing output Y_1 and $c_{Y1}(.)$ is the unit cost function. The output-constrained input demand functions can be derived by applying Shephard's lemma. Imposing zero homogeneity in input prices allows the cross-price elasticity terms to be expressed in terms of cost shares and the elasticity of substitution between inputs via the Allen decomposition of output-constrained input demand elasticities.

The output-constrained input demand of Bali beef production by the wet market:

(3) $Y_3 = Y_1\ c'_{Y1,Y3}(Y_{16}, Y_{19}, Y_{47})$ *demand for carcass from public abattoirs*

(4) $Y_9 = Y_1\ c'_{Y1,Y9}(Y_{16}, Y_{19}, Y_{47})$ *demand for marketing input 1*

(5) $Y_{46} = Y_1\ c'_{Y1,Y46}(Y_{16}, Y_{19}, Y_{47})$ *demand for carcass from private abattoirs*

$c'_{Y1,Yn}(Y_{16}, Y_{19}, Y_{47})$ (n=3, 9 ,46) are partial derivatives of the unit cost functions $cy1(Y_{16}, Y_{19}, Y_{47})$.

Marketing input supply to Bali beef production at Bali wet market:

(6) $Y_{19}=b(Y_9, T_{y9})$ *supply of marketing input 1*

Bali public abattoir carcass production function

(7) $Y_{16}=d(Y_{18}, Y_{21})$

This equation expresses the long-run equilibrium condition that output price equals average per unit cost d(.).

Total cost function at public abattoirs can be written as:

$C_{Y3}=Y_3*c_{Y3}(Y_{18}, Y_{21})$

C_{Y3} is the total cost of producing output Y_3 and $c_{Y3}(.)$ is the unit cost function. The output-constrained input demand functions can be derived by applying Shephard's lemma. Imposing zero homogeneity in input prices allows the cross-price elasticity terms to be expressed in terms of cost shares and the elasticity of substitution between inputs via the Allen decomposition of output-constrained input demand elasticities.

Output-constrained input demand of carcass production at Bali public abattoirs

(8) $Y_6=Y_3*c'_{Y3,Y6}(Y_{18}, Y_{21})$ *demand for Bali cattle at public abattoirs*

(9) $Y_{11}=Y_3*c'_{Y3,Y11}(Y_{18}, Y_{21})$ *demand for marketing input 3*

$c'_{Y3,Yn}(Y_{18}, Y_{21})$ (n=6, 11) are partial derivatives of the unit cost functions $cy3(Y_{18}, Y_{21})$.

Marketing input supply to carcass production at Bali public abattoirs

(10) $Y_{21}=e(Y_{11}, T_{y11})$ *supply of marketing input 3*

Demand for Bali beef at Bali HRI market

(11) $Y_{15}=f(Y_2, N_{y2}, X_1)$

Supply function of Bali beef at Bali HRI market

(12) $Y_{15}=g(Y_{17}, Y_{20})$

Output-constrained input demand of Bali beef production at Bali HRI market

(13) $Y_4=Y_2*c'_{Y2,Y4}(Y_{17}, Y_{20})$ *demand for carcass at private abattoirs*

(14) $Y_{10}=Y_2*c'_{Y2,Y10}(Y_{17}, Y_{20})$ *demand for marketing input 2*

Marketing input supply to Bali beef production at Bali HRI market

(15) $Y_{20}=h(Y_{10}, T_{y10})$ *supply of marketing input 2*

Bali private abattoir carcass production function

(16) $Z_{BO}(Y_4, Y_{46}) = Z_{BI}(Y_7, Y_{12})$ *quantity equilibrium of carcass production*

Equation (16) is the product transformation function for the processing sector that equalises the aggregated output index Z_{BO} with the aggregated input index Z_{BI}.

(17) $r_{ZBO}(Y_{17}, Y_{47}) = c_{ZBI}(Y_{18}, Y_{22})$ *value equilibrium*

Equation (17) is an equilibrium condition stating that the unit revenue r_{ZBO} earned per unit of aggregated input Z_{BI} equals the unit cost c_{ZBI} of producing a unit of aggregated output Z_{BO}.

Input-constrained output supply of carcass at Bali private abattoirs

(18) $Y_4=Z_{BI}*r'_{ZBI,\ Y4}(Y_{17}, Y_{47})$

(19) $Y_{46}=Z_{BI}*r'_{ZBI,\ Y46}(Y_{17}, Y_{47})$

Output-constrained input demand of carcass production at Bali private abattoirs

(20) $Y_7=Z_{BO}*c'_{ZBO,Y7}(Y_{18}, Y_{22})$

(21) $Y_{12}=Z_{BO}*c'_{ZBO,Y12}(Y_{18}, Y_{22})$

Marketing input supply to carcass production at private abattoirs in Bali

(22) $Y_{22}=i(Y_{12}, T_{y12})$ *supply of marketing input 4*

Demand for imported beef in Bali

(23) $Y_{13}=j(X_1, N_{x1}, Y_{15})$

Inter-island Bali cattle demand

(24) $Y_8=k(Y_{18}, N_{y8})$

Bali cattle supply to Bali and ROI markets

(25) $Y_{18}=q(Y_5, T_{y5})$

Market clearance of Bali cattle

(26) $Y_5=Y_6+Y_7+Y_8$

The Model in Equilibrium Displacement Form

The Equation (1)- (26) defines the equilibrium status of all markets included in the model. When there is improved productivity in cattle production or other government policy causes a small shift from equilibrium, changes in prices and quantities can be approximated linearly by totally differentiating the equations (1)-(26) and converting them to elasticity form. The model in displacement form is presented in Equation (1)' – (26)'. E(.) = Δ(.)/(.) denotes a percentage change of variable (.). Exogenous shifters such as EN(.) and ET(.) are expressed as relative changes in prices.

Demand for Bali beef at wet market

(1)' $EY_{14} = 1/\eta_{(y1,y14)}\, EY_1 + EN_{y1}$

Supply function of Bali beef at Bali wet market

(2)' $EY_{14} = s_{y3}EY_{16} + s_{y9}EY_{19} + s_{y46}EY_{47}$

Output-constrained input demand of Bali beef production at Bali wet market

(3)' $EY_3 = -\left(s_{y9}\sigma_{(y3,y9)} + s_{y46}\sigma_{(y3,y46)}\right)EY_{16} + s_{y9}\sigma_{(y3,y9)}EY_{19} + s_{y46}\sigma_{(y3,y46)}EY_{47} + EY_1$

(4)' $EY_9 = s_{y3}\sigma_{(y3,y9)}EY_{16} - \left(s_{y3}\sigma_{(y3,y9)} + s_{y46}\sigma_{(y9,y46)}\right)EY_{19} + s_{y46}\sigma_{(y9,y46)}EY_{47} + EY_1$

(5)' $EY_{46} = s_{y3}\sigma_{(y3,y46)}EY_{16} + s_{y9}\sigma_{(y9,y46)}EY_{19} - \left(s_{y3}\sigma_{(y3,y46)} + s_{y9}\sigma_{(y9,y46)}\right)EY_{47} + EY_1$

Marketing input supply to Bali beef production at Bali wet market

(6)' $EY_{19} = 1/\varepsilon_{(y9,y19)}\, EY_9 + ET_{y9}$

Bali public abattoir carcass production function

(7)' $EY_{16} = s_{y6}EY_{18} + s_{y11}EY_{21}$

Output-constrained input demand of carcass production at Bali public abattoirs

(8)' $EY_6 = -s_{y11}\sigma_{(y6,y11)}EY_{18} + s_{y11}\sigma_{(y6,y11)}EY_{21} + EY_3$

(9)' $EY_{11} = s_{y6}\sigma_{(y6,y11)}EY_{18} - s_{y6}\sigma_{(y6,y11)}EY_{21} + EY_3$

Marketing input supply to carcass production at Bali wet market

(10)' $EY_{21} = 1/\varepsilon_{(y11,y21)}\, EY_{11} + ET_{y11}$

Demand for Bali beef at Bali HRI market

(11)' $EY_{15} = (1/\eta_{(y2,y15)})EY_2 + EN_{y2} + (1/\eta_{(y2,x1)})EX_1$

Supply function of Bali beef at Bali HRI market

(12)' $EY_{15} = s_{y4}EY_{17} + s_{y10}EY_{20}$

Output-constrained input demand of Bali beef production at Bali HRI market

(13)' $EY_{4} = -s_{y10}\sigma_{(y4,y10)}EY_{17} + s_{y10}\sigma_{(y4,y10)}EY_{20} + EY_{2}$

(14)' $EY_{10} = s_{y4}\sigma_{(y4,y10)}EY_{17} - s_{y4}\sigma_{(y4,y10)}EY_{20} + EY_{2}$

Marketing input supply to Bali beef production at Bali HRI market

(15)' $EY_{20} = 1/\varepsilon_{(y10,y20)}\, EY_{10} + ET_{y10}$

Bali private abattoir carcass production function

(16)' $\gamma_{y4}EY_{4} + \gamma_{y46}EY_{46} = s_{y7}EY_{7} + s_{y12}EY_{12}$

(17)' $\gamma_{y4}EY_{17} + \gamma_{y46}EY_{47} = s_{y7}EY_{18} + s_{y12}EY_{22}$

Input-constrained output supply of carcass at private abattoirs

(18)' $EY_{4} = -\gamma_{y46}\tau_{(y4,y46)}EY_{17} + \gamma_{y46}\tau_{(y4,y46)}EY_{47} + EZ_{BI}$

(19)' $EY_{46} = \gamma_{y4}\tau_{(y4,y46)}EY_{17} - \gamma_{y4}\tau_{(y4,y46)}EY_{47} + EZ_{BI}$

Output-constrained input demand of carcass production at private abattoirs

(20)' $EY_{7} = -s_{y12}\sigma_{(y7,y12)}EY_{18} + s_{y12}\sigma_{(y7,y12)}EY_{22} + EZ_{BO}$

(21)' $EY_{12} = s_{y7}\sigma_{(y7,y12)}EY_{18} - s_{y7}\sigma_{(y7,y12)}EY_{22} + EZ_{BO}$

Marketing input supply to carcass production at private abattoir

(22)' $EY_{22} = 1/\varepsilon_{(y12,y12)}\, EY_{12} + ET_{y12}$

Demand for imported beef in Bali

(23)' $EY_{13} = \eta_{(y13,x1)}EX_{1} + EN_{x1} + \eta_{(y13,y15)}EY_{15}$

Inter-island Bali cattle demand

(24)' $EY_{8} = 1/\eta_{(y8,y18)}\, EY_{18} + EN_{y8}$

Bali cattle supply

(25)' $EY_{18} = 1/\varepsilon_{(y5,y18)}\, EY_{5} + ET_{y5}$

Bali cattle market clearance

(26)' $EY_{5} = \rho_{y6}EY_{6} + \rho_{y7}EY_{7} + \rho_{y8}EY_{8}$