Project 32326 CP88923

33rd Annual Conference of the
Australian Agricultural Economics Society
Lincoln College, Christchurch, New Zealand 7-9 February 1989

WHY HAS THE SUPPLY OF BEEF IN JAPAN GROWN SO RAPIDLY?

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The supply of beef in Japan has been growing rapidly since the 1960s. This output growth, sourced mainly from dairy breed animals, has occurred while the meat industry's rate of protection has declined relative to other agriculture.

This paper presents a partial-equilibrium econometric model of the Japanese dairy beef sector. The model is used to assess the major factors which have influenced growth in dairy beef production. The paper concludes that input costs appear to have a greater influence on production than price. This is discussed within the context of Japanese agricultural policy.

Research on this project was supported by a grant from the Australian Meat and Live-stock Research and Development Corporation. The comments and assistance of Joe Dewbre were essential to this research.

One objective of Japanese agricultural policy is to achieve high levels of self-sufficiency (BAE 1981, 1987; ABARE 1988). It has been argued that to meet this objective high rates of agricultural protection have been imposed (Longworth 1983). A policy objective of self-sufficiency implies that changing consumption patterns must be reflected in changing production. Since the Second World War the main change in Japanese consumption patterns has been a shift from 'traditional' foods, such as rice and fish, to 'non-traditional' ones such as meat and products based on wheaten flour (Longworth 1983, pp 8-9).

In 1960-61, chicken, pork and beef were consumed in similar amounts, per person. By 1984-85 per person beef consumption was less than half that of either chicken or pork (MAFF 1985). These differential rates of growth in consumption were reflected in production, the growth rates for chicken and pork being more than twice that for beef. The more rapid rates of growth for chicken and pork have been achieved with rates of protection far below those of beef. While there has been no trend in the protection afforded to beef (Teal et al. 1988) - and the same is true of other meats - the protection for grains has steadily increased since the 1950s, with the result that by 1980-82 the meat sector as a whole was the least protected sector of Japanese agriculture (Anderson, Hayami, Honma, Saxon and Shei 1986, p.129).

Despite the declining relative rate of protection for beef, domestic supply growth has been rapid. Longworth (1983, ch. 4 and 5) describes how the source of domestic beef supply has shifted from the traditional source, wagyu breed cattle, to dairy breed cattle. The nature of these changes is discussed by Simpson, Yoshida, Miyazaki and Kada (1985). Several attempts have been made to model this supply response (Kagatsume and Zwart 1983; Liu 1985; Tyers and Anderson 1986; and Wahl, Hayes and Williams 1987). These studies differ markedly in both the approach adopted and the supply elasticities reported.

It is the intention in this paper to extend this supply response work in several respects. In the next section, a brief description of the dairy beef industry is given and is used as the basis for a model of the supply of beef from dairy breed cattle (hereafter referred to as dairy beef). In the following sections the performance of the model is assessed, and estimated supply elasticities are reported and compared with those obtained in earlier studies. The price variables of importance in determining supply changes are identified and the question posed in the title of this paper is answered. The paper concludes with a discussion of the problems currently faced by Japanese policy makers in relation to beef production and trade.

The Japanese Dairy Beef Industry

The Japanese dairy beef industry has been changing rapidly over the period 1965 to 1986. It is not the aim of this paper to describe the industry and its related policies in detail (for a detailed description see ABARE 1988). However, three integrally related changes in industry characteristics which have affected dairy beef supply, and hence 'the model' specification used in this study, require discussion. First, there has been a dramatic reduction in the number of dairy calves slaughtered, despite increasing dairy cow numbers; second, the average slaughter weight of dairy cattle has increased; and third, returns to beef producers have risen substantially since the late 1970s and early 1980s.

In the three-year period 1963-65, an average of 239 000 dairy calves were slaughtered annually. In 1986, only 28 000 calves were slaughtered.

This nearly tenfold decrease occurred despite an increase in the number of calves available for slaughter: the dairy cow inventory averaged some 1.3 million head in the period 1963-65 and rose to 2.1 million head by 1986. This reduction in calf slaughter - which occurred mainly during the early to mid-1970s - has been an important factor contributing to the increase in dairy beef production and has undoubtedly been influenced by the gross margins earned from fattening dairy breed cattle.

Turning to the second point: in the period from 1970 to 1986 the average slaughter weight of dairy steers increased by 34 per cent while that of dairy cows and heifers increased by 32 per cent. In the late 1960s and early 1970s, substantial productivity gains were made with dairy cattle through the adoption of the feedlot system of fattening and the introduction of feeding arrangements more suited to the dairy breed. The returns to the industry since the late 1960s have benefited from the adoption and implementation of these new technologies. For the future, however, the opportunities for increases in dairy beef production through technological innovation (in the forms of either increases in average slaughter weight, increased calving rates or diet improvement) are regarded as relatively limited (Simpson et al. 1985, pp.133-47).

The returns to dairy beef production, as measured by the wholesale price of dairy steers relative to the import cost of feed grains, have risen consistently since 1965, and dairy beef production has increased accordingly. Longworth (1983) has pointed out that 'the feed-price/dairy-beef-price ratio appears to be the single major variable determining dairy-beef output' (p.284) - a significant factor which has been captured in the model developed here. Between 1981 and 1986 the cost of feed grains to domestic producers fell by over 50 per cent, contributing substantially to the rise in returns to beef producers.

Modelling Japanese beef supply

In the literature published in English, two approaches have been adopted in the modelling of Japan's beef supply. In the first, used by Kagatsume and Zwart (1983), Liu (1985) and Wahl et al. (1987), it is the dynamics of herd size and slaughter which are modelled. In the second, adopted by Tyers and Anderson (1986), beef supply is estimated as a function of real prices to producers. This second approach provides what is, in effect, a reduced form relative to the first, by omitting the industry dynamics.

These studies differ not only in the structure of their models but in the generality of their specifications regarding substitution within the meat sector and between livestock and grains. Liu (1985) and Kagatsume and Zwart (1983) adopt a partial equilibrium approach. Tyers and Anderson (1986) report cross-price elasticities of beef supply with respect to both coarse grains and non-ruminant meat (chicken and pork).

Both Liu (1985) and Tyers and Anderson (1986) present supply elasticities. The results presented by Kagatsume and Zwart are multipliers, from which elasticities cannot be directly inferred. The long run supply elasticities reported by Liu (p.29) and Tyers and Anderson (p.156) are radically different - respectively, 0.18 and 0.8. As their modelling approaches differ, it is clearly important to establish whether these are due to the approach used or to some other factors.

Most Japanese agriculture is subject to policy regulation, and the dairy beef industry is no exception. The dairy beef industry is affected by wholesale price stabilisation, feeder calf price stabilisation and the various arrangements influencing milk production including milk quotas and the milk price stabilisation arrangements (Longworth 1983; ABARE 1988). However, producers can still respond to changing input and output prices. It is therefore possible to model the Japanese dairy beef industry using a structural, partial equilibrium approach. There are two reasons for selecting this approach. The first is its greater generality compared with the 'reduced form' method used by Tyers and Anderson (1986). The second is that, because a similar approach has been used in ABARE to model beef supply in other major beef producing countries, the results obtained can be compared with those for such countries.

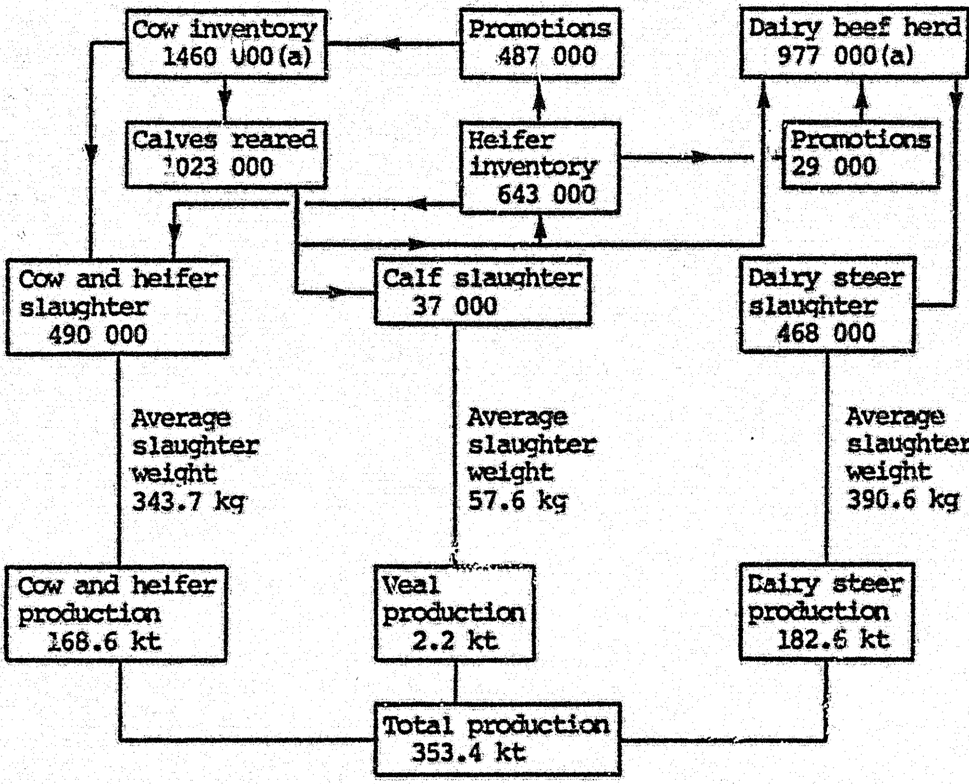
The method used to model producers' response is, in essence, to model the variables that determine inventory size. The most important of these is the decision variable of how many head of cattle to slaughter. This decision influences both current output (by changing supply) and future output (by altering herd inventories). This modelling approach differs from that of Liu (1985) and Wahl et al (1987) who represent inventories by behavioral equations. The advantage of modelling slaughter is that it provides additional structural information as to the nature of the supply response. It is an approach similar to that used by Dewbre, Shaw, Corra and Harris (1985) to estimate beef supply in Australia.

The model reported in this paper provides only a partial equilibrium analysis of beef supply, rather than including other meat industries in an integrated system. This choice was made not on a priori grounds but after attempts to model substitution within the meat sector had failed to show significant substitution effects. That such substitution could occur is obvious. However, a consequence of Japanese policy is that, since a major objective is self-sufficiency, real returns to one sector relative to another can be allowed to alter only slightly. Thus the use of partial equilibrium analysis is justified as it focuses on the essentials of the Japanese policy makers' problem: beef output must be expanded but not at any substantial expense to other agricultural sectors.

Finally, the model presented here is only for dairy beef. Of the total increase in beef supply of 344 kt over the period 1965 to 1985, 87 per cent was sourced from dairy breed cattle (MAFF 1986a). Thus a model explaining the supply of beef from dairy cattle will clearly capture the major causes of supply growth over the last twenty years.

The structure of the model is shown in Figure 1. (An appendix gives details of the model, including the coefficients and diagnostic results for each equation.) The size of the dairy cow herd (KC) determines the number of calves reared (C) (assuming a constant reproductive technology). The calves are either allocated to the heifer or dairy beef herds, or slaughtered to produce veal. The heifers have three potential uses: to be included in the slaughter of the cows (SC), to be used to restock the cow herd (PF), and as inputs into the dairy beef herd (PM).

The dairy inventory thus consists of three components, the inputs to each being determined by the allocation of the calves reared. These three components are: first, the dairy cow inventory, which is the female dairy herd over two years of age (KC); second, the dairy heifer inventory, which is the female dairy herd under two years of age (KV); and third, the dairy steer inventory (KB), which consists of dairy steers and that part of the female inventory allocated to beef production. Estimates of these inventories for 1985 are included in Figure 1.



(a) As at 1 February 1986.

FIGURE 1 — Structure of the Model, Showing Figures for 1985

These relationships are expressed by the following identities, which form the basis of the model. (j indicates the current year.)

(1) Dairy cow inventory:

$$KC_j = KC_{j-1} - SC_j + PF_j$$

where SC is cow and heifer slaughter and PF is promotions to the cow inventory.

(2) Dairy heifer inventory:

$$KV_j = KV_{j-1} + 0.5\ C_j - PF_j - PM_j$$

where C is calves reared and PM is promotions to the dairy beef inventory.

(3) Dairy male inventory:

$$KB_j = KB_{j-1} - SB_j + PM_j - SV_j + 0.5\ C_j$$

where SB is slaughter of dairy beef and SV is slaughter of calves.

The number of promotions and number of calves reared are simply modelled as functions of inventory size (equations A15-17, appendix). Though, in principle, the decision between promoting calves to the cow and beef herds will depend on relative returns, the returns variable was omitted from the equations because its coefficient was found insignificant.

The slaughter of dairy cows and heifers is specified as a function of a returns variable and lagged inventories. Initially, an attempt was made to model the returns variable as the sum of returns from milk production, salvage value of milking cows and the sale of feeder calves, using three-year moving averages deflated by the cost of feed grains and interest rates. On estimating a slaughter rate equation in which all the returns components were thus separate independent variables, the feeder calf price coefficient was found to be highly significant but positive (contrary to expectations). Therefore, the constraint that all three components should appear in the returns variable was relaxed and an alternative returns variable was defined, as:

$$E_j = \Sigma(i = j\text{-}2,\ j\text{-}1,\ j)\ ((PM_i.M_i + P_i.WC_i)/F_i)/3$$

where PM is the farmers' sale price of milk (¥/kg), M is the production of milk per cow (kg/hd), P is the price of dairy steer beef (¥/kg), WC is the average slaughter weight of cows and heifers (kg/hd) and F is an index of the imported cost of feed grains. (For a detailed description of this index see the footnote to the data listing in the appendix.)

As can be seen, this measure includes the returns to milk production and a return to dairy beef production, and enters the equation as a three-year moving average deflated by feed grain costs. It is recognised that the variable only proxies returns to dairy producers, rather than including all returns. However, the diagnostics of the dairy cow and heifer slaughter equation (equation A5, appendix) strongly support the exclusion of feeder calf prices.

The returns variable (EB) that determines calf slaughter is analogous to the beef return component of the returns variable specified above; that is:

$$EB = \Sigma(i = j\text{-}2,\ j\text{-}1,\ j)\ (P_i.WB_i/F_i)/3.$$

The calf slaughter equation (equation A7, appendix) is specified as a function of this returns variable. As the proportion of calves reared which are slaughtered, SV/C, necessarily varies between zero and unity, this variable is modelled using the function:

$$((SV_j/C_j)/(1 - SV_j/C_j) = \exp(\alpha - \beta \log EB) + E_t.$$

This specification was found to model the variable adequately.

The equations for the slaughter of cows and heifers and for calves are the major behavioral equations determining inventory size. The remaining determinant of beef production is average slaughter weight. In the estimated model the average slaughter weights of calves, cows and heifers, and steers are modelled as functions of the ratio of the wholesale price of beef to imported feed grain costs (equations A8-10, appendix). These specifications attempt to capture the trade-off between returns and costs faced by beef fatteners. As the output price (P.WB) increases, or as the input cost (F) decreases, the return to fattening rises. The average slaughter weight of the animals can rise, up to some practical limit, thus increasing total production. The equations are specified in a form which allows for this upper limit: average slaughter weight is specified as a function of the inverse of the output price. In the cow and heifer and calf equations, time was also included in an inverse form which captures the reducing returns to fattening livestock.

As is summarised in Figure 1, these factors - inventory changes, numbers slaughtered and average slaughter weight - all interact to determine the final components of total dairy beef production: namely, veal, beef sourced from both cows and heifers, and dairy steers.

Performance of the Model

To assess the performance of the model, two kinds of validation experiment were performed. The first type of experiment consisted of a comparison of static and dynamic simulations with historical data over the period 1975-86. A static simulation uses actual values of lagged endogenous variables while a dynamic simulation uses prior-period model solutions for those variables. The means of the actual and simulated data for the major model variables are presented in Table 1. In most cases the model replicates historical data well, with dynamic simulation errors of less than 11 per cent. The exceptions (not shown) are the promotion of heifers to the dairy beef herd, the slaughter of calves and the quantity of dairy veal produced. These variables are very small, and their simulation errors are small in absolute terms.

The second type of validation experiment concerned the stability and dynamic behavioral characteristics of the model. These experiments consisted in setting all exogenous variables to the same values for all periods (in effect making all exogenous variables additional parameters of the model) and solving the model a sufficient number of periods forward to discover whether the solutions converged or diverged. In a number of such experiments, each involving different starting values for lagged endogenous variables the model solutions for all endogenous variables converged. This procedure is analogous to the determination, for linear models, of properties of characteristic roots. Though not constituting a formal mathematical proof of model stability, the results of these simulations provide empirical evidence of stability.

Dairy Beef Supply Response

To summarise the behaviour of the model, supply elasticities are presented in Table 2. Supply elasticities for total dairy beef and for beef from dairy steers and from cows and heifers are shown with respect to the wholesale price of beef, the farmers' sale price of milk, imported feed grain costs and the domestic interest rate. The elasticities were estimated from experimental runs of the system of supply equations; an outline of this procedure can be found in Dewbre et al. (1985). Such elasticities are explicitly time-dimensioned. The simulations were performed using the 1975 and 1985 values of the exogenous variables. Because many of the elasticities from these two simulations were found to be markedly different, both sets of elasticities are presented.

The negative elasticities after one year with respect to both the beef and milk prices are indicative of the 'slaughter now or retain' option. They indicate that, when faced with increasing prices, producers suspend or reduce slaughter in the short term, and thus forgo a certain return in the expectation of increased future returns.

The medium and long term elasticities indicate a larger response to beef price changes than to milk price changes.

TABLE 1

Static and Dynamic Simulation Performance: 1975 to 1986

Variable	Unit	Actual mean	Static		Dynamic	
			Mean	RMS error	Mean	RMS error
				%		%
Slaughter of dairy steers	'000 hd	393.1	386.5	10.1	374.8	11.2
Slaughter of dairy cows and heifers	'000 hd	421.7	423.7	7.3	388.5	9.7
Average slaughter weight of dairy steers	kg	354.2	354.5	1.2	357.2	1.4
Average slaughter weight of dairy cows and heifers	kg	319.3	320.2	1.6	320.2	1.6
Average slaughter weight of dairy calves	kg	45.0	45.2	4.9	45.7	5.5
Inventory of dairy steers	'000 hd	754.7	757.4	4.5	720.0	6.4
Inventory of dairy cows	'000 hd	1 423.5	1 409.0	2 4	1 370.9	4.3
Inventory of dairy heifers	'000 hd	617.4	624.5	1.9	596.2	5.0
Dairy calves reared	'000 hd	947.6	938.7	6.3	882.0	8.3
Promotions of heifers to the dairy cow herd	'000 hd	442.1	429.5	7.0	408.2	8.8
Dairy steer production	kt	140.7	138.7	9.5	135.4	10.8
Dairy cow and heifer production	kt	135.7	136.4	8.7	125.0	10.0
Total dairy beef production	kt	276.4	277.6	7.9	262.8	8.9

TABLE 2

Elasticities of Dairy Beef Supply with Respect to Prices and Interest Rate, by Simulation

With respect to:	Wholesale beef price (P)			Milk price (PM)			Feed grains index (F)			Interest rates (N)		
Period	Q(a)	[illegible]	QC(c)	Q	QB	QC	Q	QB	QC	Q	QB	QC
1975 sample set												
After 1 year	-0.023	-0.291	-0.029	-0.010	-0.291	-0.021	0.031	0.0	0.047	0.069	-0.291	0.145
After 5 years	0.408	0.764	0.092	0.021	0.026	[illegible]	-0.472	-0.0	-0.112	-0.084	-0.091	-0.075
After 10 years	0.679	1.260	0.195	0.082	0.082	[illegible]	-0.819	-0.875	-0.274	-0.209	-0.223	-0.209
Long run(d)	0.919	1.590	0.297	0.146	0.143	[illegible]	-1.123	-1.877	-0.431	-0.333	-0.327	-0.339
1985 data set												
After 1 year	-0.016	0.0	-0.028	-0.009	0.0	-0.022	0.024	0.0	0.046	0.063	0.0	0.145
After 5 years	0.181	0.285	0.072	0.027	0.030	0.024	-0.223	-0.343	-0.097	-0.098	-0.101	-0.094
After 10 years	0.345	0.499	0.173	0.095	0.092	0.098	-0.453	-0.625	-0.264	-0.229	-0.224	-0.237
Long run	0.482	0.684	0.252	0.152	0.150	0.155	-0.641	-0.866	-0.391	-0.334	-0.329	-0.339

(a) Total quantity supplied of dairy beef and veal. (b) Quantity supplied of dairy steer beef. (c) Quantity supplied of dairy cow and heifer beef.
(d) The result for 2020 (after 34 years).

Both feed grain costs and interest rates enter the model as denominators of the beef and dairy returns variables. As Table 2 indicates, supply is very sensitive to the cost of feed grains.

It is also of note that dairy steer beef production is more responsive than is production from dairy cows and heifers to both the wholesale price of beef and the imported feed grain index. Although the production of beef from male dairy breed cattle has traditionally been seen as a sideline operation (Longworth 1983, p. 38), these results suggest that such production has been highly responsive to price.

When the elasticities obtained using the 1985 exogenous variables are compared with those from the 1975 data, a reduced responsiveness to wholesale beef prices and imported feed grain costs is seen, though little change is observed with respect to either milk prices or interest rates. It is possible that this reduction in elasticity is due to the lower level of calf slaughter in the 1980s relative to the late 1960s and early 1970s - that is, further substantial reduction in calf slaughter is no longer available as a means of increasing dairy beef herd size in response to beef price improvement, and thus responsiveness has necessarily diminished.

Comparison with Other Results

Presented in Table 3 a [illegible] of elasticity and other response estimates from oth[illegible] sources. Tyers and Anderson (1986) estimated a supply elastici[illegible] for 'ruminant meat' (beef and sheep meat) in Japan. This, it will be noted, is very close to the long run elasticity in the model using the 1975 data.

TABLE 3

Alternative Japanese Beef Supply Response Estimates

Source	Variable	Price variable	Type of measure	Value
Tyers and Anderson (1986)	Ruminant meat	World beef price	Long run elasticity	0.80
Liu (1985)	Wagyu and dairy steer beef production	Beef price/ feed grains index	Current price elasticity	0.17
			Lagged price elasticity	0.01
Kagatzume and Zwart (1983)	Dairy beef production	Stabilisation price	Short run(a)	0.01
			Long run(a)	0.44
		Feed grains index/ beef price	Short run(a)	-0.09
			Long run(a)	-0.43

(a) Supply multipliers, not elasticities.

Liu (1985) estimated current and lagged elasticities of supply with respect to the price of beef. The beef price was defined relative to the cost of feed grains and is therefore identical to the price variable used in this paper. The coefficient on this beef price/feed cost ratio, reported as a supply elasticity, appears in the Liu model in an average slaughter weight equation. When the beef component of the Liu model was placed in a partial equilibrium framework similar to that used for the present model, two problems were encountered. The first was that the model was unstable: an exogenous 'shock' to the price term led to an infinite rise in output. The second was that the elasticity of supply with respect to price was found to be negative. This latter result occurred because the elasticity of stock additions with respect to price was lower than that of slaughters; thus the net effect of a price rise was to lower inventories and ultimately slaughters and output.

The results from the model presented in this paper are, for the early part of the sample period, consistent with the results of Tyers and Anderson (1986). The supply elasticity now appears to be substantially below the Tyers and Anderson estimate. The implications of this result will be considered in the final section.

Why Beef Output Has Grown

The production of beef from dairy breed animals has grown rapidly since the 1970s. Over the period 1971-75, an annual average of 173 kt of dairy beef was produced. By 1986 the figure had approximately doubled to 362 kt. Production from dairy steers alone rose from an average of 71 kt per year in the period 1971-75 to 187 kt in 1986. (Prior to 1967 this category was not even officially recorded.) The growth in the production of beef from dairy breed animals (ΔQ) may be decomposed into two components: changes in average slaughter weight (ΔW) and in slaughter numbers (ΔS). Thus:

$$Q = W \Delta S + S \Delta W + \Delta W \Delta S.$$

This identity has been calculated and is tabulated in Table 4. It can be seen that the changes in slaughter numbers alone (closely proportional to inventory increases, since slaughter rates have changed very little) account for some 67 per cent and 56 per cent of the growth in the production from dairy steers and cows and heifers, respectively. The growth in average slaughter weight alone contributed only some 16 per cent to the growth in the production of beef from dairy steers, but a substantial 32 per cent to that of dairy cows and heifers.

What has determined these changes in slaughter weight and numbers? Counterfactual simulation using the model provides one way of answering this question. The estimated error terms are included in the model, so that it replicates history. An exogenous variable is then 'shocked' and the model is run to determine the effect on the final out-turn (in this case, total dairy beef production). The difference between the level of production in the counterfactual simulation and the historical level indicates the estimated influence that the exogenous variable has had on the growth in production.

The results of such counterfactual simulations are presented in Table 5. The historical production and inventories for 1975 and 1985 are shown in the first two lines. When wholesale beef prices were held constant at their 1975 level, total production and inventories for 1985 were reduced by 2.4 per cent and 1.1 per cent respectively. Holding the feed grain cost index and interest rates, in turn, constant at their 1975 levels (which were higher

TABLE 4

Composition of Dairy Beef Production Growth

Sector and year(s)	Average slaughter weight	Average annual slaughter number	Annual production	Decomposition of increase					
	W	S	W.S	W.ΔS		S.ΔW		ΔW.ΔS	
	kg	'000 hd/year	kt/year	kt/year	%(a)	kt/year	%	kt/year	%
Dairy steers									
1971-75	316.7	225.5	71.4						
1986	396.9	470.0	186.5	77.4	67.3	18.1	15.7	19.6	17.0
Dairy cows and heifers									
1971-75	282.7	361.4	102.2						
1986	346.9	504.0	174.9	40.3	55.5	23.2	31.9	9.2	12.6

(a) Proportions of total growth accounted for by the component.

TABLE 5

Counterfactual Simulation Results for Dairy Beef Production and Inventories

	Year	Production			Inventories		
		Dairy females	Dairy males	Total(a)	Dairy females	Dairy males	Total
		kt	kt	kt	'000 hd	'000 hd	'000 hd
Historical variables	1975	112.9	109.0	225.6	1 808.3	485.2	2 293.5
	1985	168.6	182.7	353.4	2 103.0	977.0	3 080.0
<u>Simulations</u>							
Wholesale beef price constant at 1975 level	1985	166.8	175.8	345.0	2 090.7	954.3	3 045.0
		(-1.1)	(-3.8)	(-3.1)	(-0.6)	(-2.3)	(-1.1)
Feed grains index constant at 1975 level	1985	156.2	141.1	301.5	2 001.0	814.3	2 815.4
		(-7.4)	(-22.8)	(-14.7)	(-4.9)	(-16.7)	(-8.6)
Interest rates constant at 1975 level	1986	142.4	156.8	301.0	1 881.9	816.6	2 698.5
		(-15.5)	(-14.2)	(-14.8)	(-10.5)	(-16.4)	(-12.4)

(a) Includes dairy veal production.
Note: Figures in parentheses are percentage differences between actual and simulated production in 1985.

than subsequent levels) reduced production by 14.7 per cent and 14.8 per cent respectively, and inventories by 8.6 and 12.4 per cent respectively.

The results for the components of beef production (dairy steer and cow beef production) are also presented. Notably, dairy steer production was reduced by 23 per cent when the feed grain index was held at its 1975 level, while the production of beef from cows and heifers was reduced by only 7.4 per cent.

These counterfactual simulations indicate that the growth in dairy beef production since the mid-1970s has been due primarily to the reduction in input prices over this period, and not to increases in output prices. The rapid growth of supply can be attributed to policy measures which have reduced input prices, rather than to increased prices for the output.

Policy Implications

Japanese policy toward beef has been of major importance in the restructuring of the Japanese agricultural sector which has occurred over the last twenty years. Table 6 shows the extent of that change. The meat sector has been by far the most important source of growth in agriculture. Its share in production rose nearly threefold, from 6.2 per cent in 1965 to 17.8 per cent in 1985. It is important also to note that only cereals and pulses have undergone any fall in output, and that fall has been modest. Thus, the expansion in Japan's meat output has not been at the expense of other agricultural sectors.

Further, within the meat sector, production of each of the major meats has grown at roughly similar rates despite the higher levels of nominal protection for beef relative to pork and chicken, reflecting the higher cost of beef production relative to other meats. Thus, it appears that beef returns, and hence beef production, have been maintained by a combination of beef price protection and access to feed grains at close to world prices.

Liberalisation of the Japanese beef market - that is, removal of beef quotas - would induce substitution in demand; the evidence for this is discussed by Teal et al. (1988). However, little substitution in meat production would be expected, because chicken and pork production are already internationally competitive. Thus, the consequences of liberalisation for meat production would be largely determined by the magnitude of the own-price supply elasticity of beef.

The potential consequences of liberalisation of agriculture generally have been considered by Tyers and Anderson (1986) and OECD (1987). As has been noted, Tyers and Anderson estimated the price elasticity of beef supply as 0.8. The OECD study gives no information on specific supply elasticities, but does report aggregate agriculture supply elasticities for the OECD countries covered. Japanese agriculture appears to have the highest supply elasticity of all OECD countries - more than twice that of Australia.

The implication of these high elasticities is that trade liberalisation would result in large changes in net trade volumes - for beef, according to Tyers and Anderson (1986, p. 53), a nearly tenfold increase in imports to Japan. This predicted consequence is of course regarded as a major gain by those favouring liberalisation and as a major threat by Japanese policy makers concerned to maintain self-sufficiency.

TABLE 6

Value of Production for Japan's Agricultural Commodities at 1980 Producer Prices(a)(b)

Commodity	1965		1970		1975		1980		1985	
	Ym	%	Ym	%	Ym	%	Ym	%	Ym	%
Rice	3 798	39.5	3 884	37.3	4 030	37.2	2 985	28.0	3 570	30.1
Other cereal and pulses	1 285	13.4	738	7.1	463	4.3	531	5.0	648	5.5
Fruit and vegetables	2 649	27.5	3 000	28.8	3 181	29.4	3 223	30.2	3 361	28.3
Industrial crops	220	2.3	240	2.3	235	2.2	269	2.5	293	2.5
Milk and eggs	616	6.4	989	9.5	1 025	9.5	1 242	11.6	1 370	11.5
Other livestock	458	4.8	618	5.9	604	5.6	665	6.2	604	5.1
Meat	594	6.2	947	9.1	1 292	11.9	1 748	16.4	2 026	17.8
Beef and veal	288	3.0	371	3.6	468	4.5	556	5.2	731	6.2
Pig meat	235	2.4	424	4.1	601	5.6	807	7.6	886	7.5
Chicken	61	0.6	147	1.4	221	2.0	337	3.2	407	3.4
Other	9	0.1	5	-	2	-	2	-	2	-
Total	9 621	100	10 415	100	10 829	100	10 662	100	11 870	100

(a) All prices are simple averages of the sub-categories available. (b) Price series (1980) were sourced from MAFF (1986a, pp.247-80). Exceptions to this were: sugar cane (Industrial crops), MAFF (1986a, p.197); sugar beet (Industrial crops) indexed to sugar cane price; beef, medium grade wholesale price of dairy steers, MAFF (1986b, p.60); chicken, wholesale price dressed broiler, MAFF (1986b, p.61); Pork, medium grade wholesale price, MAFF (1986b, p.61); veal, as for beef; horsemeat (Other), Unit value of imports, MAFF (1986b, p.85); other meat (Other), average of pork, chicken and horsemeat; silk (Other livestock), spot quotation, MAFF (1986a, p.131); milk, MAFF (1986a, p.197) and LIPC (1987, pp.18-21); other dairy products (Other livestock), MAFF (1986b, pp.61 and 85) and LIPC (1987, pp.18-21).

The results of this study suggest that for beef the price elasticity is currently much lower than that used by Tyers and Anderson (1986) - that it has in the recent past been very close to that used by Tyers and Anderson, but has fallen by nearly half over the period 1975 to 1985.

In general, a policy of increasing both domestic production and imports of any product is difficult to implement, as raising prices to producers reduces consumption. Hence, increases in output induced by high producer and thus consumer prices generally entail reduced imports. In contrast, Japanese policy makers have been able to expand both output and imports of beef. Between 1978 and 1987, output increased by 166 kt (carcass weight) and imports by a slightly larger 184 kt.

The key to this outcome has been the fall in input prices relative to output prices. As the counterfactual simulations have shown, declines in input prices were a much more important determinant of output increases than rises in output prices. These price reductions have been due in part to falling import prices. Though Japan has not, in the past, had an explicit policy objective of beef import growth, the results clearly suggest how Japan can meet both domestic pressures for maintaining output and international pressures for trade liberalisation. From a trade viewpoint, the removal of all tariffs and quotas would be the preferred option to Australian policy makers; a second-best option, which would still enable both output and imports to grow, would be a policy change from output price control to input subsidy. The costs of this policy change, together with those of market liberalisation, are topics of current ABARE research.

APPENDIX

The Model and Estimation Results

Data Listing

Variable	Definition	Unit	Source
SB	Slaughter of dairy steers	hd	MAFF (1986b)
SC	Slaughter of dairy cows and heifers	hd	MAFF (1986b)
SV	Slaughter of dairy calves	hd	MAFF (1986b)
PF	Promotion of heifers to the dairy cow herd	hd	Derived from equations A2-4
PM	Promotion of heifers to the dairy steer herd	hd	Derived from equations A2-4
WC	Average slaughter weight of dairy cows and heifers	kg	Derived (QC/SC)
WB	Average slaughter weight of dairy steers	kg	Derived (QB/SB)
WV	Average slaughter weight of dairy calves	kg	Derived (QV/SV)
KC	Closing inventory of dairy cows	hd	MAFF (1986a)
KV	Closing inventory of dairy heifers	hd	MAFF (1986a)
KB	Closing inventory of dairy steers	hd	MAFF (1986a)
C	Calves reared	hd	Derived from equations A2-4
E	Returns to dairy producers	Y/hd	Derived from equation A1
Q	Total quantity supplied, dairy breed beef	kt	MAFF (1986b)
QC	Quantity supplied from dairy cows and heifers	kt	MAFF (1986b)
QB	Quantity supplied from dairy steers	kt	MAFF (1986b)
QV	Quantity of dairy veal supplied	kt	MAFF (1986b)
F(1)	Index of imported feed grain costs	Index	Derived from Japan Tariff Association (1986)

(continued)

Variable	Definition	Unit	Source
M	Supply of milk per head	kg/hd	Derived (total milk fat production/KG)
P	Wholesale price of medium grade dairy steer beef	Y/kg	MAFF (1986b), LIPC (1987)
PM	Farmers' sale price of milk	Y/kg	LIPC (1987)
N	Nominal interest rate, unconditional call money, short term quotation, Japan	Index	International Monetary Fund (1987)
T	Time	1950=1	Derived

(1) Calculated using base weights for 1980 (MAFF 1980). The prices are represented by the unit values of imports, which include those of 'other wheat' (10.01-911), barley (10.03-011), maize (10.05-010) and kao-liang (10.07-310) (Japan Tariff Association 1986). Durum wheat and soybeans were excluded as they would have restricted estimation to 1976-86. This variable was seen as most appropriate for use in this supply model as it reflected changes in world feed grain prices and therefore allowed simulation of the effects of changing world feed grain prices on Japanese dairy beef supply. Furthermore, this index was found to correlate closely with prices paid for feed concentrates by Japanese farmers.

Model Equations

Equation A1: Expected real dairy returns

$$E_j = \Sigma\ (i = j\text{-}2,\ j\text{-}1,\ j)\ ((PM_i . MPi + WCi . Pi)/F_i)/3$$

Equation A2: Dairy cow inventory (over 2 years of age)

$$K_j = KC_{j-1} - SC_j + PF_j$$

Equation A3: Dairy beef inventory

$$KB_j = PM_j + KB_{j-1} - SV_j - SB_j + 0.5\ C_j$$

Equation A4: Dairy heifer inventory (under 2 years of age)

$$KV_j = KV_{j-1} + 0.5\ C_j - PF_j - 2M_j$$

Equation A5: Dairy cow and heifer slaughter

$$\log SC_j = \underset{(-3.386)}{-19.491} - \underset{(-2.389)}{0.151} \log(E_j/N_j) + \underset{(5.526)}{2.368} \log KC_{j-1}$$

Range 1972 to 1985 NOB = 14 NOVAR = 3

$R^2 = 0.757$ $CR^2 = 0.713$ $F(2/11) = 17.168$

SER = 0.091 SSR = 0.091 DW = 1.782 Cond. = 596.26

SC - Dynamic and static simulation results(a)

	Actual	Static			Dynamic		
			Error	Percentage error		Error	Percentage error
Mean	421 695	423 677	1 982.3	1.2162	388 529	-33 165.8	-7.479
RMS	426 195	426 309	26 896.6	7.327	392 002	41 170.5	9.709
Std dev.	64 785	49 599.1	28 133	7.579	54 601.5	25 584	6.518

(a) These and following simulations were over the period 1975-86.

Equation A6: Dairy beef slaughter

$$\log SB_j = \underset{(0.536)}{0.776} + \underset{(8.263)}{0.898} \log KB_{j-1}$$

Range 1972 to 1985 NOB = 14 NOVAR = 2

$R^2 = 0.851$ $CR^2 = 0.838$ $F(11/11) = 68.278$

SER = 0.133 SSR = 0.[illegible]2 DW = 2.414 Cond. = 81.60

SB - Dynamic and static simulation results

	Actual	Static			Dynamic		
			Error	Percentage error		Error	Percentage error
Mean	393 120	386 456	-6 663.1	-1.513	374 760	-18 359.5	-3.723
RMS	400 347	395 440	33 372	10.1170	380 724	35 892.5	11.239
Std dev.	79 423.8	87 903.7	34 296.1	10.491	70 402.2	32 346.9	11.123

Equation A7: Slaughter of dairy calves

$$\log((SV_j/C_j)/(1-SV_j/C_j)) = 19.234 - 2.306 \log(\hat{\Sigma}(i = j-2, j-1, j)\ (P_i.WC_i/F_i))$$
$$(4.261)(-4.842)$$

Range 1972 to 1985 NOB = 14 NOVAR = 2

$R^2 = 0.661$ $CR^2 = 0.633$ $F(2/11) = 86.211$

SER = 0.392 SSR = 1.842 DW = 1.945 Cond. = 86.212

SV - Dynamic and static simulation results

	Actual	Static			Dynamic		
			Error	Percentage error		Error	Percentage error
Mean	58 250.5	58 731.5	481.01	6.357	54 842.7	-3 407.7	-1.519
RMS	64 002.8	63 034.3	18 644.6	29.415	59 466.8	18 196.1	27.348
Std dev.	27 812.9	24 006.9	19 548.2	30.121	24 112.8	18 766.6	28.639

Equation A8: Slaughter weights of dairy cows

$$WC_j = 482.501 - 229.347\ (1/(P_{j-1}/F_{j-1})) - 4406.84\ (1/T)$$
$$(44.217)\quad(-3.178)\qquad(-13.143)$$

Range 1972 to 1985 NOB = 14 NOVAR = 3

$R^2 = 0.958$ $CR^2 = 0.950$ $F(1/12) = 125.67$

SER = 5.601 SSR = 345.039 DW = 1.109 Cond. = 17.720

WC - Dynamic and static simulation results

	Actual	Static			Dynamic		
			Error	Percentage error		Error	Percentage error
Mean	319.322	320.225	0.903	0.336	320.225	0.903	0.336
RMS	319.978	320.753	4.952	1.602	320.753	4.952	1.602
Std dev.	21.487	19.297	5.107	1.643	19.297	5.107	1.643

Equation A9: Slaughter weight of dairy beef animals

$$WB_j = \underset{(4.258)}{75.720} - \underset{(-4.948)}{293.17}\,(1/(P_{j-1}/F_{j-1})) + \underset{(18.509)}{0.866}\,WB_{j-1}$$

Range 1972 to 1985 NOB = 14 NOVAR = [illegible]

$R^2 = 0.976$ $CR^2 = 0.972$ $F(1/11) = 223.456$

SER = 4.798 SSR = 253.204 DW = 2.115 Cond. = 31.730

WB - Dynamic and static simulation results

	Actual	Static			Dynamic		
			Error	Percentage error		Error	Percentage error
Mean	354.203	354.492	0.288	0.097	357.193	2.989	0.825
RMS	354.896	355.151	4.323	1.247	357.975	5.076	1.428
Std dev.	23.248	22.695	4.524	1.304	24.8[illegible]7	4.302	1.222

Equation A10: Slaughter weight of dairy calves

$$WV_j = \underset{(2.143)}{50.319} - \underset{(-1.864)}{90.808}\,(1/(P_{j-1}/F_{j-1})) + \underset{(2.500)}{0.556}\,WV_{j-1} - \underset{(-1.508)}{659.966}\,(1/T)$$

Range 1972 to 1985 NOB = 14 NOVAR = 4

$R^2 = 0.893$ $CR^2 = 0.861$ $F(3/10) = 27.761$

SER = 3.767 SSR = 141.918 DW = 2.201 Cond. = 56.805

WV - Dynamic and static simulation results

	Actual	Static			Dynamic		
			Error	Percentage error		Error	Percentage error
Mean	45.001	45.170	0.169	1.028	45.723	0.723	2.364
RMS	45.991	45.949	2.216	4.857	46.465	2.292	5.533
Std dev.	9.958	8.835	2.317	4.979	8.672	2.281	5.247

Equation A16: Promotions of dairy heifers to the greater-than-two-year herd

$$\log PF_j = -5.915 + 1.418 \log KV_{j-1}$$
$$(-1.110) \quad (3.540)$$

Range 1972 to 1985   NOB = 14   NOVAR = 2

R^2 = 0.510 CR^2 = 0.470   F(1/12) = 12.530

SER = 0.106   SSR = 0.136   DW = 1.215   Cond. = 375.011

PF - Dynamic and static simulation results

	Actual	Static	Static Error	Static Percentage error	Dynamic	Dynamic Error	Dynamic Percentage error
Mean	442 158	429 538	-12 611.9	-2.623	408 238	-33 911.9	-7.555
RMS	444 158	431 375	38 684	7.042	410 119	39 622	8.794
Std dev.	442 944	41 713.3	29 337.6	6.854	41 152.6	21 491.4	4.720

Equation A17: Promotions of females to the dairy beef herd

$$PM_j = 0.343\ PM_{j-1} + 0.027\ KV_{j-1}$$
$$(1.387) \quad (2.037)$$

Range 1972 to 1985   NOB = 14   NOVAR = 2

R^2 = 0.724 CR^2 = 0.701   F(2/12) = NA

SER = 17492.6   SSR = 3.67E +09   DW = 1.932   Cond. = 3.111

PM - Dynamic and static simulation results

	Actual	Static	Static Error	Static Percentage error	Dynamic	Dynamic Error	Dynamic Percentage error
Mean	23 164.6	24 211.6	1 046.9	15.669	24 002.7	838.11	105.242
RMS	29 179.2	25 119.5	15.442.6	162.84	24 067.6	17 110.7	452.358
Std dev.	18 609.4	7 019.25	16 159	169.99	1 852.6	17 924.4	461.419

<u>Equation A11</u>: **Beef production from dairy cows and heifers**

$$QC_j = WC_j.SC_j/1000\ 000$$

<u>Equation A12</u>: **Dairy beef production**

$$QB_j = WB_j.SB_j/1000\ 000$$

<u>Equation A13</u>: **Dairy beef calf veal production**

$$QV_j = WV_j.SV_j/1000\ 000$$

<u>Equation A14</u>: **Total dairy beef and veal production**

$$Q_j = QC_j + QB_j + QV_j$$

Q - Dynamic and static simulation results

	Actual	Static			Dynamic		
			Error	Percentage error		Error	Percentage error
Mean	275.447	277.641	1.194	1.046	262.816	0.723	-4.119
RMS	283.111	283.775	16.078	7.887	268.172	2.292	8.945
Std dev.	64.047	61.545	16.076	8.199	55.932	2.281	8.328

<u>Equation A15</u>: **Dairy calves reared**

$$\log C_j = -9.597 + 1.650 \log KC_{j-1}$$
$$(-1.964)\ (4.768)$$

Range 1972 to 1985 NOB = 14 NOVAR = 2

$R^2 = 0.6544$ $CR^2 = 0.6257$ $F(1/12) = 22.731$

SER = 0.101 SSR = 0.122 DW = 2.518 Cond. = 362.107

C - Dynamic and static simulation results

	Actual	Static			Dynamic		
			Error	Percentage error		Error	Percentage error
Mean	947 593	938 668	-8 924.8	-0.782	882 012	-65 580.1	-6.323
RMS	951 493	942 910	55 832.5	6.281	886 043	77 753.3	0.320
Std dev.	90 267.5	93 700.9	57 804.6	6.536	88 539.2	43 810	4.995

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