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Working Paper No. 38

The Distribution of Benefits from Improved Animal Health Decision Making as a Result of the Collection of Additional Animal Health Information

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Gavin Ramsay, Clem Tisdell and S.R. Harrison

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Gavin Ramsay[2], Clem Tisdell[3] and S.R. Harrison[4]

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The Commissioned Organization is the Queensland Department of Primary Industries. Collaborating institutions in Australia are CSIRO-ANHL, Geelong, Victoria and the University of Queensland (Department of Economics; Department of Geographical Sciences and Planning). In Thailand, the collaborating institutions are the Department of Livestock Development (National Institute of Animal Health; Disease Control Division), Chiang Mai University (Department of Agricultural Economics; Department of Animal Husbandry) and Thammasat University (Faculty of Economics). The collaborating institution in Laos is the Department of Livestock and Veterinary Services. Dr F.C. Baldock, Senior Principal Epidemiologist, Queensland Department of Primary Industries is the Project Leader in Australia and Dr P. Chamnanpood, Senior Epidemiologist, Thai Department of Livestock Development is the Project Leader in Thailand. Professor Clem Tisdell and Dr Steve Harrison, Department of Economics, University of Queensland are responsible mainly for the economic component of this project.

'The overall goal of this project is to develop and evaluate the .necessary tools to provide decision-makers with reliable animal health information which is placed in context and analysed appropriately in both Thailand and Australia. This goal will be achieved by improving laboratory diagnostic procedures; undertaking research to obtain cost-effective population referenced data; integrating data sets using modern information management technology, namely a Geographical Information System (GIS); and providing a framework for the economic evaluation of the impact of animal diseases and their control.

A number of important diseases will be targeted in the project to test the systems being developed. In Thailand, the focus will be on smallholder livestock systems. In Australia, research will be directed at the northern beef industry as animal health information for this sector of livestock production is presently scarce.'

For more information on *Research Papers and Reports Animal Health Economics* write to Professor Clem Tisdell (c.tisdell@economics.uq.edu.au) or Dr Steve Harrison,(s.harrison@uq.edu.au) Department of Economics, University of Queensland, Brisbane, Australia, 4072.

The Distribution of Benefits from Improved Animal Health Decision Making as a Result of the Collection of Additional Animal Health Information

ABSTRACT

This paper firstly examines the international beef market, then the concept of economic surplus and the effects of the collection of additional animal health information on the aggregate beef supply curve. The effects of movements in the beef supply curve on domestic producer and consumer surplus are then determined. In development of the model, the effects of a shift in the supply curve in an unrestricted domestic market are examined. A free international trade model is then developed followed by a model that includes the effects of trade restrictions in the form of quotas.

Keywords: Animal health, Pacific rim, Australia, international trade, *Babesia bovis*

JEL Classification: Q160

The Distribution of Benefits from Improved Animal Health Decision Making as a Result of the Collection of Additional Animal Health Information

1. Introduction

The gathering of additional animal health information can have effects on the beef supply curve by increasing the efficiency of beef production. The use of additional information by individual livestock producers to improve the efficiency of production has been examined in Discussion Paper 36. The analysis in that paper assumes that an increase in productivity will not affect beef prices and that benefits derived from additional information flow to beef producers. However, an increase in the supply of beef can affect market prices and the benefits of improved efficiency of production are distributed between various sections of the community. If government is involved in collection of additional animal health information and if producers are required to contribute to the cost of its collection it is important to determine who benefits from that information.

The distribution of the benefits from improved efficiency of production is determined in this paper using the concept of economic surplus. This analysis includes the distribution of the benefits between producers and consumers. This paper firstly examines the international beef market, then the concept of economic surplus and the effects of the collection of additional animal health information on the aggregate beef supply curve. The effects of movements in the beef supply curve on domestic producer and consumer surplus are then determined.

In development of the model, the effects of a shift in the supply curve in an unrestricted domestic market are examined. A free international trade model is then developed followed by a model that includes the effects of trade restrictions in the form of quotas.

2. Australian Beef Export Markets

The export market for Australian beef is affected by tariffs and import restrictions. While these barriers to trade are being reduced progressively the market is still far from allowing free trade. The beef market is outlined in this section with emphasis on the Pacific Rim

market as a first step in determining the effects of a shift in the beef supply curve in Central Queensland.

Most of Australia's exports of beef are consigned to countries in the Pacific Rim. The United States and Japan are the main importers. In 1993 these two countries imported approximately 70% of the beef and veal exported from Australia. The importing countries and the quantity of Australian beef they import are presented in Table 1.

Table 1: Major importers of Australian beef and veal

Country	Import volume (kt boneless beef)	
	1992	1993
United States	371.7 (45.2%)	274.4 (34.7%)
Japan	217.7 (26.5%)	280.5 (35.5%)
Canada	51.8 (6.3%)	84.3 (10.7%)
Republic of Korea	97.3 (11.8%)	53.1 (6.7%)
Taiwan	36.5 (4.4%)	32.8 (4.2%)
Papua New Guinea and the Pacific Islands	12.1 (1.5%)	12.3 (1.6%)
United Kingdom	6.1 (0.7%)	5.2 (0.6%)
Total exported	822.5	790.4

Source: ABARE (1994).

The beef market in the Pacific Rim is highly regulated with most countries including the United States and Japan imposing trade restrictions. In the United States the restrictions take the form of "voluntary" limitations on the quantity exported by a country to the United States in association with tariffs. In Japan restrictions take the form of *ad valorum* tariffs together with a system of quotas (Harris et al., 1990; Reithmuller et al., 1990)

The major beef producing countries are indicated in Table 2. Australia is a relatively small beef producer in international terms providing 3.6% of total world production. The United States, producing 20%, and the European Union, producing 16% are the major world producers.

Table 2: Major world producers of beef and veal by country

Country	Quantity (kt Carcass weight)	
	1992 (kt carcass weight)	Percentage of world total
Australia	1 834	3.60%
Argentina	2 520	4.96%
Brazil	3 950	7.77%
Canada	910	1.79%
Columbia	630	1.24%
European Union	8 367	16.46%
Japan	592	1.16%
Mexico	1 660	3.27%
New Zealand	518	1.02%
South Africa	745	1.47%
Former Soviet Union	6 494	12.77%
United States	10 613	20.88%
World	50 835	

Source: ABARE (1994).

The details of major exporting countries are presented in Table 3. The data in Table 3 demonstrates that Australia is a major exporter of beef and in both 1992 and 1993 was the largest exporter of beef and veal in the world. The European Union is the next largest exporter followed by the United States.

Table 3: Major exporters of beef and veal

Country	Quantity exported (kt carcass weight)	
	1992	1993
Australia	1197	1146
European Union	1139	1096
United States	601	578
New Zealand	426	456
Argentina	296	275
Canada	159	190
Uruguay	123	104
China	75	140
India	77	90
Costa Rica	22	25
Sweden	8	8

Source: ABARE (1994).

3. Use of Economic Surplus for the Assessment of Improved Animal Health Information

An important consideration in the evaluation of the benefit of animal health information is the distribution within the society of those benefits. The calculation of economic surplus usually includes both the distribution and the magnitude of benefits. Economic surplus is made up of two parts, namely; benefits to producers or producer surplus and benefits to consumers or consumer surplus, and is defined as the sum of the two components. Economic surplus has been used by several authors to examine the benefits of specific animal health activities (Anaman et al., 1994; Berentsen et al., 1992; Ott et al., 1995; Ebel et al., 1992; Amosson et al., 1981).

Consumer surplus arises when the market price is less than the consumers are prepared to pay, while producer surplus occurs when market prices exceed production costs. Producer and consumer surplus can be demonstrated by the use of supply and demand curves as illustrated in Figure 1.

Consumer surplus is the difference between the consumers' willingness to pay for the quantity that is consumed Q and the amount actually paid. The area under the demand curve and above the quantity axis is the amount consumers are willing to pay while the area below the price line PM is the amount actually paid. Therefore, the consumer surplus is area BMQO less area PMQO. This can be reduced to the area BMP which is the area under the demand curve and above the price line (Just et al., 1982 p. 72).

The producer surplus is made up of the gross return to the producer minus the variable costs. The gross return is the quantity times the price and is area PMQO while variable costs are the area under the supply curve AMQO. The producer surplus is the difference between the two, PMA. If the supply curve corresponds to the marginal cost curve this area is also the profit earned by producers.

If either the supply curve or demand curves or both shift there will be a change in the economic surplus. The change can occur in producer surplus, consumer surplus or both.

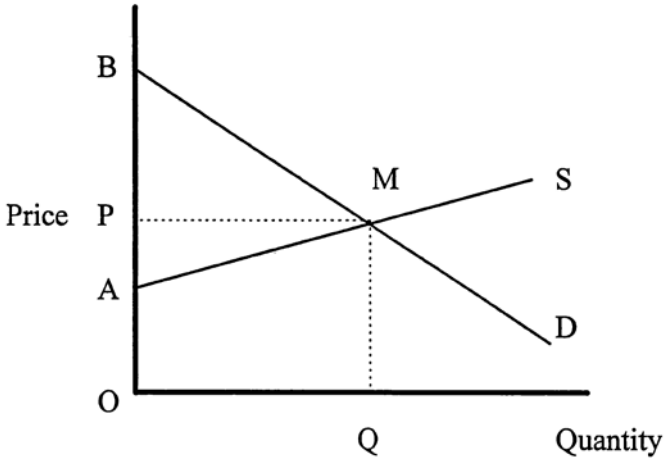

Figure 1: Producer and consumer surplus

4. The Effect of Shifts in the Supply Curve on Economic Surplus Without Trade

In this section the change in producer surplus with a shift in the supply curve is examined. The effects of different types of shifts in the supply curve are then examined in following sections. The factors that affect the size and distribution of economic surplus are then determined.

The change in economic surplus is the change in producer surplus plus the change in consumer surplus. In Figure 2 the change in consumer surplus is shown as the area $P_0M_0M_1P_1$. The change in producer surplus is the area $P_1M_1A_1$ less the area $P_0M_0A_0$. This can be reduced to the area $A_0M_0M_1A_1$.

The level and type of shift in the supply curve in response to the availability of additional animal health information depends on several factors, including:

- the effect of the additional information in improving the efficiency of beef production
- the variation in the improvement of efficiency in different geographical areas and production systems
- the level, distribution and timing of the uptake of the information.

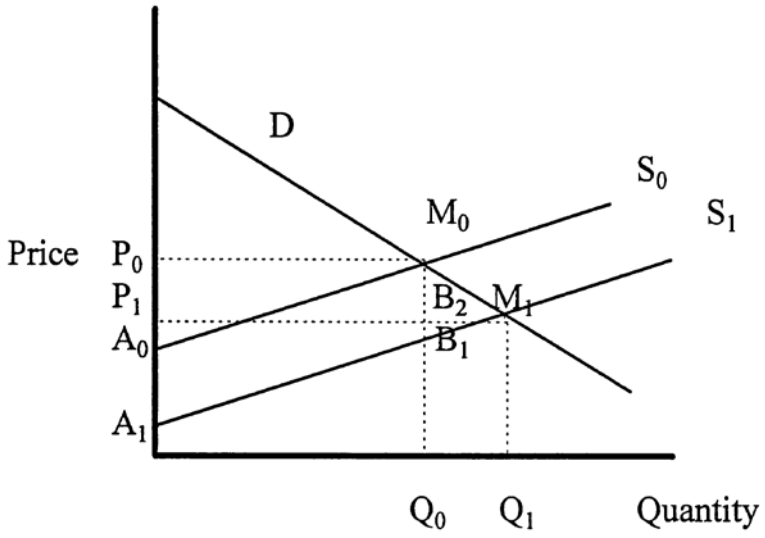

Figure 2: The change in economic surplus with a change in supply

As discussed in Paper 36 additional animal health information can be used by individual livestock producers to reduce the efficiency gap. Where producers make use of the additional information the supply curve will move to the right (Ott et al., 1995).

Two principal types of supply shift are distinguished by Lindner and Jarrett (1978), namely divergent and convergent, with the parallel shift between these two types. The change in economic surplus has been shown to vary considerably with different types of shift in the supply curve (Lindner and Jarrett, 1978; Rose, 1980; Wise and Fell, 1980). Differences in the size of economic surplus as large as three fold were estimated for different types of shift in the supply curve (Lindner and Jarrett, 1978). The effects of various types of shift in the supply curve on producer surplus alone were examined by Miller et al. (1988).

The effects of divergent convergent and parallel shifts of the supply curve on producer and consumer surplus are examined in the following sections. This examination includes the factors that determine the size and distribution of benefits. Examination of the different types of supply curve shifts is important as it has been demonstrated that the type of shift in the supply curve affects the size, direction and distribution of changes in economic surplus resulting from that shift (Duncan and Tisdell, 1974; Lindner and Jarrett, 1978).

4.1 Divergent shifts to the right in supply

In divergent shifts of the supply curve the absolute vertical distance between the two supply curves increases as the quantity supplied increases (Lindner and Jarrett, 1978). Two cases of divergent shifts pivotal and proportional are illustrated in Figures 3 and 4 respectively. In the case of a divergent shift it is implied that absolute reductions in average cost are greater for marginal firms than for inframarginal firms. That is the increase in efficiency is less for the more profitable lower cost farmers at the left of the supply curve than for the less efficient farmers operating at the right of the supply curve (Lindner and Jarrett, 1978).

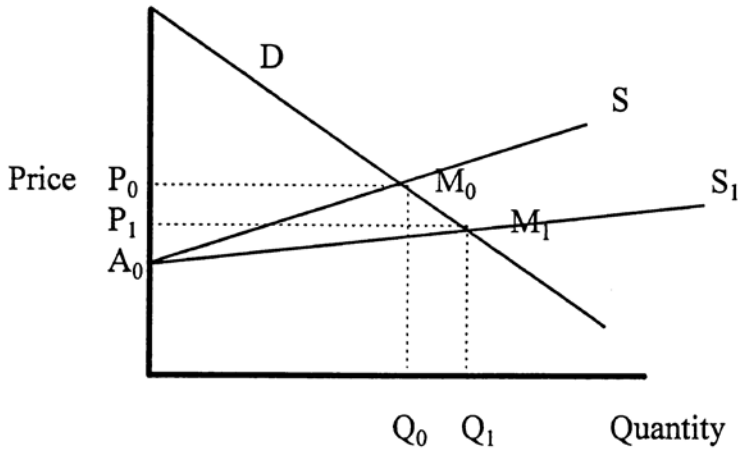

Figure 3: A pivotal shift in the supply curve

Amosson et al. (1981) assumed a pivotal shift in the supply curve when examining the implications of alternative bovine brucellosis control programs. Miller et al. (1988) examined the effects on producer surplus of pivotal shifts in the supply curve. They found that when the equilibrium lay in part of the elastic or any of the inelastic region of the demand curve a downward pivot of the supply curve will decrease producer surplus. This applies for any supply and demand functions that are linear or power functions. The implication is that as demand in agricultural markets tends to be inelastic, an analysis using a pivot of the supply curve will predetermine the nature of the change in producer surplus (Miller et al., 1988).

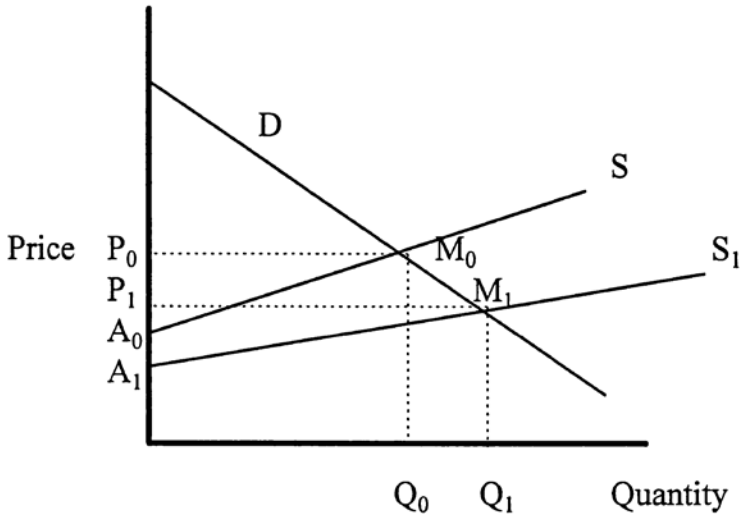

Figure 4: A proportional divergent shift in the supply curve

4.2 Convergent shift to the right in supply

A convergent shift is one where the absolute cost reduction at inframarginal levels of output is greater than at marginal levels of output. A convergent shift is presented in Figure 5 where the supply shifts from S to S_1.

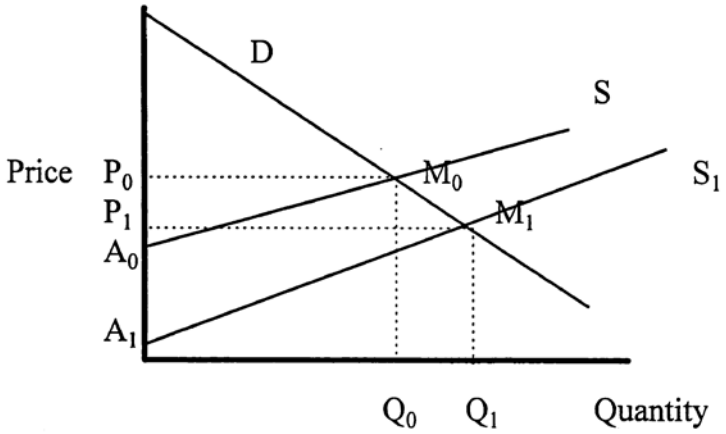

Figure 5: A convergent shift to the right in supply

Convergent shifts in the supply curve are more likely to occur with technological and organisational innovations which are scale dependant than from biological innovations (Lindner and Jarrett, 1978). For example, a technological innovation is more likely to be used by more efficient lower cost farmers. The effect therefore is to improve the efficiency of the farmers who are producing at the left of the supply curve (Lindner and Jarrett, 1978).

4.3 Parallel shift to the right in supply

Parallel shifts to the right occur when improvements in efficiency are not scale or efficiency dependant and implies the same absolute reduction in average costs for both high and low cost producers.

The effects of a parallel shift to the right are illustrated in Figure 6. The supply curve shifts from S to S 1 resulting in an increase in the consumer surplus of area $P_0M_0CP_1$. In Figure 6 it can be seen that a parallel shift in the supply curve will always result in increased consumer surplus. This is because consumers will always maintain area $P_0M_0P_2$ if supply increases. Producer surplus will also increase with a parallel movement in the supply curve if demand is not perfectly inelastic.

A parallel shift in the supply curve was assumed by Ott et al. (1995) in examining the national economic benefits of reducing livestock mortality, as did Ebel et al. (1992) when examining the welfare effects of the national pseudorabies eradication program in the USA. In both cases an increase in consumer and producer surplus was predicted. Ebel et al. (1992) examined three groups with different herd prevalences of infection separately and assumed a parallel shift for each of these as a way to determine the effect of the shift on producer surplus for each level of disease.

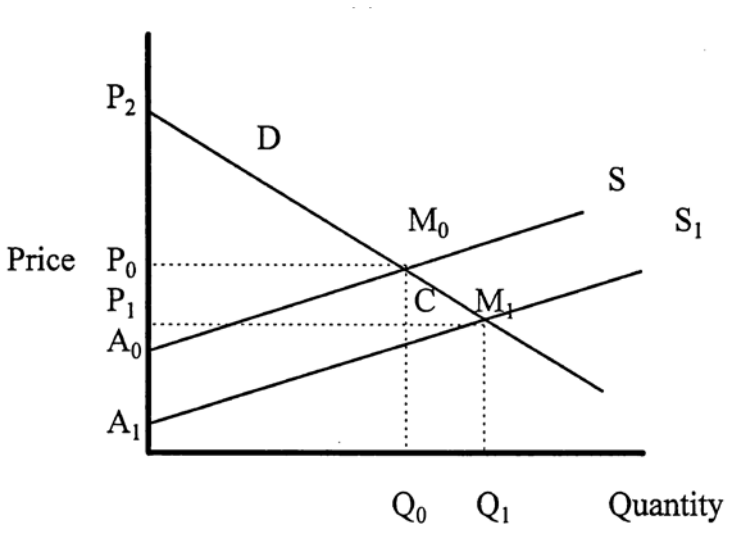

Figure 6: Market effects of improved animal production with a parallel shift in the supply curve

In each of the above examples of a shift in the supply curve to the right it can be seen that the

equilibrium price for meat would be expected to fall resulting in an increase in consumer surplus.

4.4 Factors affecting changes in economic surplus with shifts in supply

The effect of the type of shift in the supply curve on economics surplus has been demonstrated in the previous sections. Divergent shifts result in smaller benefits to producers than either parallel or convergent shifts (Norton and Davis, 1981).

Demand elasticity is also important in determining the size, direction and distribution of a change in economic surplus. This is because as the demand curve becomes more inelastic producers are more likely to have a decrease in surplus following a change in efficiency of production (Norton and Davis, 1981). In addition, if supply elasticity is larger than demand elasticity consumers will tend to receive a larger share of benefits than producers.

5. The Effect of a Shift in Supply When Beef is Exported

The effects on domestic economic surplus of a shift in the supply curve where a proportion of the beef is exported are now examined. In Section 5.1 the situation where the trade market is a free trade market is investigated while in Section 5.2 the effects of market distortions in the form of quotas and tariffs are included in the analysis.

A disaggregated commodity supply and demand model along the lines of that developed by Edwards and Freebairn (1984) is used in both sections. In this model separate sectors for the home country, Australia, and the rest of the world are specified. World demand is obtained by the horizontal summation of demand specifications for Australia and the rest of the world as illustrated in Figure 7.

5.1 The effect of a shift in beef supply when exported into a free market

This section examines the effect of a supply shift with the export of beef into a free market. Figure 7 illustrates the demand curves where beef is exported. In Figure 7 the domestic demand curve is D_d, the trade demand curve D_e and the total demand curve D_t.

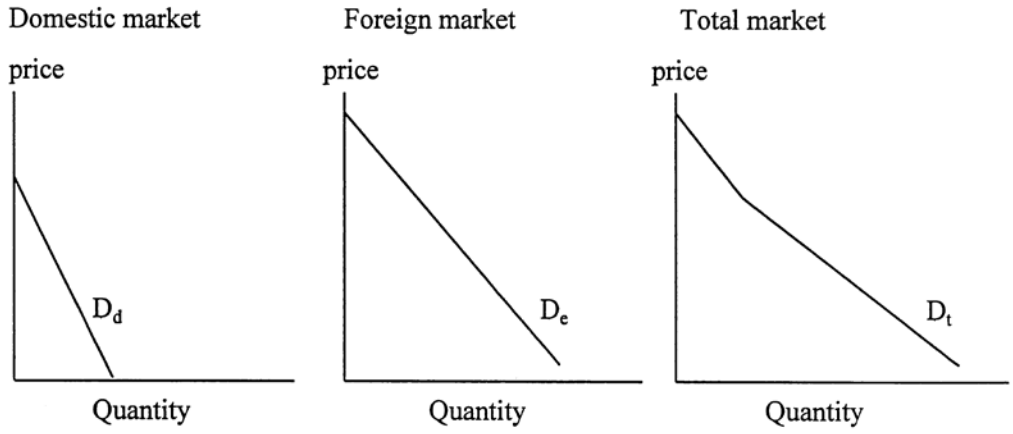

Figure 7: Demand for beef where beef is traded internationally

The total demand curve and the supply curve of domestic producers are illustrated in Figure 8. In this case a shift in supply from S_0 to S_1 results in a change in equilibrium price from P_0 to P_1 and quantity demanded from Q_0 to Q_1.

Total benefits due to a shift in supply are the area $A_0M_0M_1A_1$. The change in consumer surplus is area $P_0M_0M_1P_1$, of which $P_0C_0C_1P_1$ goes to domestic consumers and $C_0M_0M_1C_1$ goes to consumers in the rest of the world. Producer surplus equals the total benefit less consumer surplus or $A_0M_0M_1A_1$ minus $P_0M_0M_1P_1$.

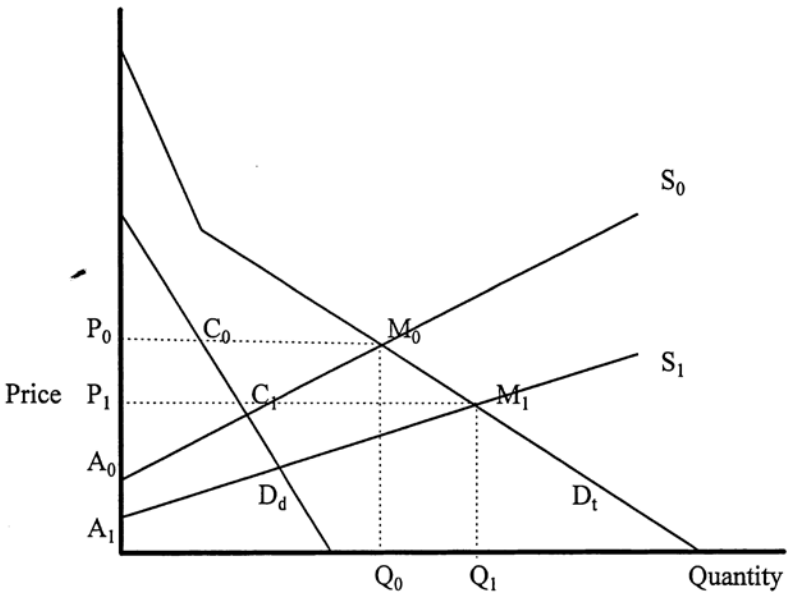

Figure 8: Benefits from a shift in beef supply due to additional animal health information in a free market with exports

The effects of a parallel shift in the supply curve within this model were assessed by Edwards and Freebairn (1984). They determined that a county's producers will always gain from a parallel supply shift when the costs in the rest of the world are not affected. A reduction in costs confined to a country comprising part of a market will reduce price less than the reduction in costs unless demand in the market as a whole is completely inelastic and supply in the whole market is perfectly elastic. Edwards and Freebairn (1984) also demonstrated that when the country being examined produces 20% or less of world production, and the shift in the supply curve occurs in both the country and the rest of the world, as long as the ratio of reduction in costs in the country to reduction in costs in the rest of the world is greater than 1:4 the country's producers will benefit. This means that while producers in a country gain less when information reduces costs in the rest of the world, as well as their own costs, they will only lose from such a shift if cost reductions in the rest of the world are considerably larger than their own.

The above information can be used to estimate whether domestic producers will benefit from a supply shift when beef is exported into a free market. As stated in Section 2 Australia produces 3.6% of the world's beef and therefore meets the criteria of a small producer country as defined in Edwards and Freebairn (1984). Australian beef producers would therefore be expected to benefit from a parallel shift to the right if the additional animal health information only increases efficiency in Australia. Australian consumers would not receive any benefit. This is because Australia is a small producer on an international scale and a small increase in beef production in Australia would be expected to have a small impact on the total amount of beef produced in the world and therefore a small impact on the world price of beef.

5.2 The effect of a shift in supply for an exporting country when an import restriction is in place

This section examines the effect of a quota or import restriction imposed by an importing country on domestic economic surplus following an improvement in the efficiency of beef production. The situation for a small producing exporting country is examined where exports are into a single large overseas market. This is the situation for Australia exporting beef into the United States market.

The effect of a production quota on the distribution of benefits when a country is a large

exporter of a good was examined by Alston et al. (1988). They determined that all of the benefits from an improvement in efficiency of production accrued to producers and quota holders and domestic consumers did not receive any benefits.

Figure 9 presents the effects of an import quota on beef demand curves. In Figure 9 D_0 represents demand in the U.S. market. The import restriction limits U.S. market demand to Q_q. The total demand curve is D_{tq} and is made up of the sum of domestic and restricted U.S. demand curves. All of the products sold into the U.S. market is sold at the U.S. market price and demand in the U.S. market is elastic. In the situation of the small producing country the import quota will not be filled while the domestic price exceeds the overseas market price (p). Once the domestic price equals the U.S. market price the import restriction would begin to be filled. While the quota is being filled the price would not vary as the quantity exported from Australia would not have an impact on total supply in the market and therefore not affect the U.S. price. When the import restriction is filled increased supply would cause the price to fall as the market is again restricted to the domestic market.

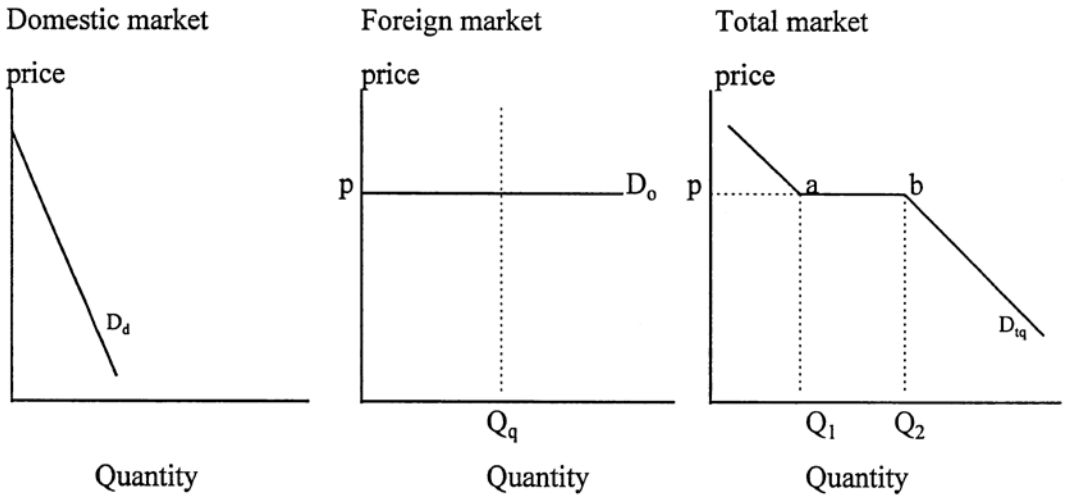

Figure 9: Effects of an import quota on beef demand curves for a small producer exporting into a large market

Figure 10 illustrates the combined domestic and trade demand curves with an import quota in place and the effects of a shift to the right in the supply curve. In this situation total benefits due to a shift in supply are the area $A_0M_0M_1A_1$. The total increase in consumer surplus is the area $P_0M_0M_1P_1$. The increase in domestic consumer surplus is area $P_0C_0C_1P_1$. The area

$C_0M_0M_1C_1$ which is the total consumer surplus less the domestic consumer surplus would not accrue to the consumers in the U.S. as the price in the U.S. would not change. This benefit would instead go to the holders of quotas.

Producer surplus equals the total benefit less consumer surplus or $A_0M_0M_1A_1$ minus $P_0M_0M_1P_1$. Whether producer surplus increases or decreases would depend on the type of shift in the supply curve and the elasticity of supply. With a pivotal shift in the supply curve it is likely that producer surplus would decrease with an import quota in place.

This examination suggests domestic consumers would benefit from a shift to the right in the supply cure where import restrictions are in place in the overseas market. This is because once import restrictions are filled the domestic price would fall. The effect on producer surplus is less clear.

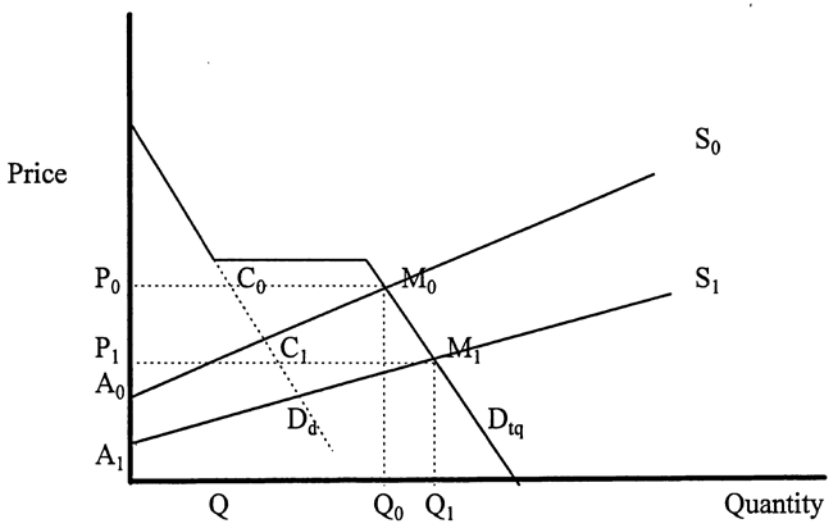

Figure 10: Effects of a quota on the distribution of domestic benefits following a shift in the beef supply curve to the right

With a quota in place and with inelastic supply the domestic price would fall (as illustrated in Figure 10). It is probable under these circumstances that most benefits from a shift in the supply curve would go to the owners of quotas and domestic consumers. The effect of the shift on beef producers' surplus is uncertain and dependant on the type of shift in the supply curve. It is possible that they may not benefit unless they are the owners of quotas.

If the export market is smaller as is the case for the Canadian market it is possible that as the quota is filled the export price will fall because enough product is exported to affect the market equilibrium. This effect is illustrated in Figure 11. Provided the price decrease is not large the effect on the distribution of benefits would be small.

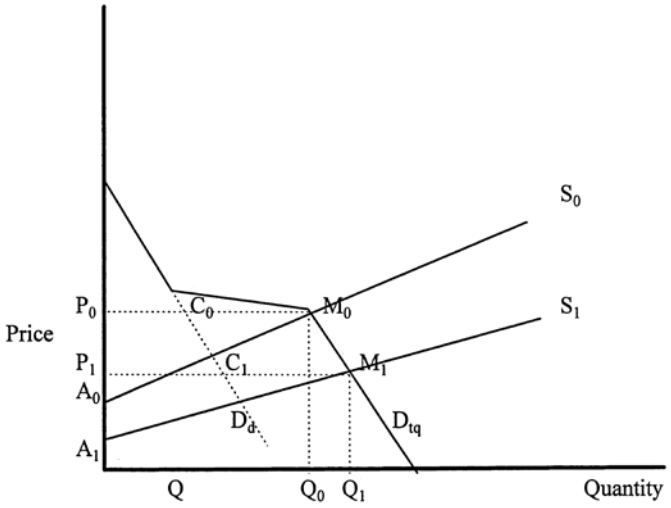

Figure 11: Effects of a quota on the distribution of domestic benefits following a shift to the right in beef supply where the export price decreases as the quota is filled

6. The Change in Producer Surplus after the Collection of Additional Information on Disease Caused by *Babesia bovis*

As demonstrated in Sections 4.1 to 4.4 the type of shift in supply plays an important role in determining whether producer surplus increases or not as a result of that shift. In this section the effect of the use of additional information on the incidence of disease caused by *B. bovis*, in disease control decisions on the Australian beef supply curve is examined.

The use of additional animal health information to improve the efficiency of beef production would probably result in shift in the Australian beef supply curve that would be divergent and to the right if the disease occurred throughout Australia. This is because many producers are already making an appropriate decision either to control or not control a disease and the additional information will not improve their efficiency. It is also likely that producers currently controlling a disease appropriately are the more efficient lower cost farmers producing at the left of the supply curve and referred to by Lindner and Jarrett (1978) as

inframarginal producers. It is therefore, producers who are not making an appropriate decision who will benefit most from the additional information and these are probably the less efficient marginal producers producing at the right of the supply curve (Lindner and Jarrett, 1978).

In this paper the effect of additional information about disease caused by *B. bovis* in Central Queensland is being examined. Disease caused by *B. bovis* only occurs in areas where the vector *Boophilus microplus* is present. Therefore, additional information on *B. bovis* would not be used by producers or affect the supply of beef outside the area where *B. microplus* occurs.

If producers in Central Queensland where disease caused by *B. bovis* occurs are inframarginal producers on the Australian beef supply curve then the shift in the supply curve shift would be convergent following the use of the additional information on disease caused by *B. bovis*. In this situation using the model developed in Section 5.2 the producers would gain from the shift with an increase in producer surplus. This is because the decrease in price is less than the increase in production. If, however the producers in Central Queensland are marginal producers then the shift in supply is likely to be divergent and in this situation it is possible that producer surplus will decrease.

7. Summary

The efficiency of beef production will increase with improved animal health decision making. The increased efficiency would lead to a shift to the right in the beef supply curve. In this the paper economic surplus is used to examine the effects of a shift in the supply curve. Initially Australia's beef market is examined followed by the concept of economic surplus. The effect of a shift in supply on economic surplus is then examined. Three markets are examined the first in which beef is not exported but is sold on a free domestic market, the second where beef is exported and the third in which beef is exported to a market affected by import quotas.

The type of shift in the supply is an important factor in determining whether producers gain from an increase in productivity while consumers always gain if the shift in supply results in a decrease in price.

In a free domestic market without exports consumers will always benefit from a shift in the supply curve as the price decreases. Producer benefits depend on the type of shift. In the case of an unrestricted export market domestic consumers would not benefit as Australia is a small producer of beef on the world scale but producers would benefit.

Where import quotas are in place as is generally the case for Australia's export markets it is predicted that domestic consumers and quota holders will benefit from a shift in the supply curve. However, in this situation it is possible that producer surplus will decrease following the shift in the supply curve.

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